FEDERAL EXPERIMENT STATION IN PUERTO RICO
of the
UNITED STATES DEPARTMENT OF AGRICULTURE
MAYAGUEZ, PUERTO RICO

REPORT OF THE FEDERAL EXPERIMENT STATION IN PUERTO RICO 1947

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FEDERAL EXPERIMENT STATION IN PUERTO RICO

MAGAGUEZ, PUERTO RICO

Administered by the Office of Experiment Stations
Agricultural Research Administration
United States Department of Agriculture

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[1] In cooperation with the Government of Puerto Rico.

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INTRODUCTION

The agricultural research program of the Federal Experiment Station in Puerto Rico has continued as in recent years to emphasize investigations which are of importance to the general welfare of continental farmers and consumers. Many of the projects, while directed toward this objective, were also of immediate and local benefit to the agricultural economy of Puerto Rico. The Insular Government has continued to support several projects which are of primary interest to Puerto Rican agriculture. Investigations partially or wholly supported by the insular funds included work on vanilla, bamboo, spices, essential oils, weed control, vegetables, and leguminous cover crops.

Closer cooperation with the various bureaus of the Department has resulted in the utilization of the station as an outpost of the Department in the Tropics. The station has cooperated closely with the Office of Foreign Agricultural Relations. Considerable quantities of plant material have been made available to this office for the development of new and complementary crops in other tropical countries of the Americas. Likewise, the lines of research being carried on at the station have contributed materially to their projects. Cooperative work with other agencies is given throughout the report.

The most outstanding contribution resulting from the work with the Insular Government has been the lath-shade method for growing vanilla. This method, developed by the station, is showing increasing promise as a method for the intensive growing of commercial vanilla in Puerto Rico. The bamboo program, sponsored both by

the Federal and Insular Governments, has also proved highly successful. Two new bamboo industries have been established, utilizing a considerable number of laborers and locally grown bamboo previously introduced by the station. The work on legumes has resulted in widespread interest in tropical kudzu. This legume promises to be a most valuable cover crop for tropical and subtropical areas.

The following pages contain summary accounts of progress of research made at this station during the fiscal year.

PERSONNEL

The following changes occurred in the Federal staff during the year: Richard H. Hageman, formerly assistant chemist at the Kentucky Agricultural Experiment Station at Lexington, joined the staff as chemist on February 12, 1947. There were two transfers: On October 20, 1946, Merriam A. Jones, chemist, transferred to the U.S.D.A. Bureau of Agricultural and Industrial Chemistry, Allergen Research Division, Washington, D. C.; and on February 9, 1947, David G. White, plant physiologist, transferred to the U.S.D.A. Plant Industry Station of the Bureau of Plant Industry, Soils, and Agricultural Engineering, at Beltsville, Md.

There were several changes during the year in the personnel employed on funds provided the station by the Government of Puerto Rico. The following appointments were made: On August 8, 1946, Carlos F. Cernuda was appointed to the position of chemist vacated by Gilda C. Vicente on August 7, 1946. On October 9, 1946, Roberto Ferrer Delgado was appointed to the position of agronomist vacated by José B. Huyke as of October 8, 1946. On July 24, 1946, José C. Mangual was appointed to the position of agronomist vacated by Mrs. Aida G. Villafañe as of July 23, 1946. Miss Nilda Acevedo was appointed clerk-stenographer, as of July 1, 1946. Mrs. Neomí G. Arrillaga, chemist, resigned December 1, 1946. Because of a reduction in funds, this position was not filled. Mrs. Iris Vera del Moral's appointment as junior clerk-stenographer was terminated as of June 30, 1947, because of the curtailment of funds.

COOPERATION WITH OTHER GOVERNMENT AGENCIES

The Government of Puerto Rico continued to support certain station activities. The Insular Legislature appropriated funds amounting to $48,490.00 for the Federal station to carry out cooperative experimental work with crops of particular interest to Puerto Rico, including vanilla, spices, essential oils, and bamboo.

The experiment station of the University of Puerto Rico and the Federal station continued close cooperation on agricultural problems. Exchange of information through conferences of the directors and members of the staffs of the two stations resulted in a well-coordinated program. The Federal station provided office and laboratory space and land facilities for the experimental work with coffee being conducted at Mayaguez by the Insular station.

The Institute of Tropical Agriculture of the University of Puerto Rico cooperated with the station in exchanging plant material, use of

laboratory facilities, and equipment. The director of the Federal station served as member of the board of trustees of the institute.

The College of Agriculture and Mechanic Arts of the University of Puerto Rico, located adjacent to the station, frequently utilized the station facilities in field demonstrations to students. The two agencies also cooperated in the installation of a new sewage line to take care of the needs of both institutions.

The extension service of the University of Puerto Rico gave the finest cooperation to the station in the distribution of plant material, particularly tropical kudzu, bamboo, and USDA–34 sweet corn.

The Federal and Insular Forest Services made labor available to the station for the propagation and distribution of newly introduced bamboos. Several thousand offsets of bamboo were planted on watersheds throughout the mountainous areas of Puerto Rico. The Insular Forest Service continued to make areas of land available at Toro Negro, Maricao, and Guánica, for the testing of various tropical plants and for the cinchona and vegetable programs of the station.

The Puerto Rico Development Co. continued cooperation with the station through the distribution of dried bamboo culms for industrial purposes. The split-bamboo fishing rod industry, established last year, continued to operate successfully, and at the close of the fiscal year plans were under way for the establishment of a new bamboo-furniture industry.

The cooperative project initiated last year with the Puerto Rico Agricultural Co. in the production of improved varieties of mangos and avocados was continued during the year.

The station cooperated with several bureaus and agencies of the Department. Office and laboratory space and land facilities were provided to the U. S. D. A. Soil Conservation Service. Office space was also made available to the Farmers Home Administration and to an Insular plant quarantine inspector who is a collaborator of the Bureau of Entomology and Plant Quarantine of the Department.

Considerable quantities of planting material were sent to the Office of Foreign Agricultural Relations for introduction and testing at cooperative experiment stations throughout Latin America. The exchange of information between both organizations was of considerable mutual benefit.

The Bureau of Plant Industry, Soils, and Agricultural Engineering, through its Division of Plant Exploration and Introduction, made available to the station a large qauntity of seed and planting material. The station was able to supply a considerable quantity of plant material in exchange.

The U. S. D. A. Regional Vegetable Breeding Laboratory at Charleston, S. C., cooperated with the station by supplying seed of promising new heat-resistant varieties of vegetables. In return the station supplied data on the performance of these new varieties under tropical conditions and also increased seed of promising material during the winter months.

A considerable number of other institutions and agencies, as well as individuals, scattered throughout the tropical world, cooperated with the station in providing planting material to add to our extensive collection of tropical plants.

INSECTICIDAL-CROP INVESTIGATIONS

DISTRIBUTION

By David G. White

Only one shipment of superior MG Derris cuttings was made.—The distribution of *Derris elliptica* (Wall.) Benth. was considerably less than in previous years. Only one shipment of 1,491 unrooted cuttings of the MG–1 clone of the Changi No. 3 variety was sent to Guatemala. A small shipment of 4 cuttings of *Lonchocarpus utilis* A. C. Smith was made to Hawaii.

PROPAGATION

By David G. White, José C. Mangual, Merriam A. Jones, and Caleb Pagán

Fertilizing derris was of no apparent value.—In October 1943 R. H. Moore[1] initiated a fertilizer experiment with the Sarawak Creeping variety of *D. elliptica*. Treatments were replicated 6 times in a lattice design. All plots consisted of 3 rows of 18 plants and were initially fertilized with ammonium sulfate at the rate of 40 pounds of nitrogen per acre. Earlier experiments had shown that a deficiency of nitrogen did not affect derris since it is a legume developing an abundance of nodules (*41*).[2] Various levels of phosphorus (as superphosphate) and potassium (as muriate of potash) were applied alone and in combination. All applications were made immediately after planting the rooted cuttings. The fertilizer was placed in bands in furrows 2½ inches deep and 4 inches from both sides of each row.

In October and early November 1945, 14 center plants of the middle row of each plot were harvested. All roots to a depth of 16 inches within a rectangle 1½ feet on either side of this row and 1 foot from each end plant were removed. Roots were washed and spread under a shelter until snap-dry and then weighed. Samples were ground and analyzed for red-color value (*26, pp. 352–359*).

No consistent differences in the average weights of roots were apparent. Treatment with 60 pounds of P_2O_5 and 240 pounds of K_2O per acre produced the largest average root weight of 948 grams per 14 plants. The lowest average root weight of 816 grams occurred when 120 pounds of P_2O_5 and 40 pounds of K_2O were applied per acre. The yields of check plots were fourth from the highest levels of both phosphorus and potassium. Extreme variations among replicates of the same treatment preclude the usefulness of statistical analysis on these data.

Differences in average red-color values among treatments were inconsistent and relatively small, ranging between 13.4 and 15.9 percent. Where derris is grown on a fairly fertile lowland Toa silty clay loam, as in this experiment, there is apparently no advantage in applying phosphorus and potassium.

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[1] Now associated with the department of horticulture, University of Nebraska, Lincoln, Nebr.

[2] Italic numbers in parentheses refer to Literature Cited, p. 81.

Total yield of rotenone was greatest 32 months after planting derris.—An experiment (*30, pp. 5–7; 63, pp. 4–6; 64, pp. 5–6; 65*) was performed to establish the relationship between yields of roots, rotenone, rotenone plus rotenoids, and chloroform extractives of *Derris elliptica* propagated from five types of cuttings and harvested at intervals up to 32 months. Roots harvested at 26 months contained the highest percentage of rotenone, rotenone plus rotenoids, and total chloroform extractives. No yield differences among the types of cuttings were found at the 14-month harvest or thereafter. Likewise, the different types of cuttings tried in this experiment were equal in production of quantity and quality of roots at maturity. Since the weight of roots and the total yield of rotenone of each successive harvest were considerably higher than those of the previous harvest, the optimum time to harvest was not established. However, it was evident that a harvest made at the end of 2 years would have been too early to obtain the greatest commercial yield. Approximately one-third of the total weight of roots from the late harvests consisted of roots larger than 8 mm. in diameter and their inclusion did not lower the persent of rotenone below buyer specifications of 5 percent.

DERRIS MULCHING EXPERIMENT

By David G. White, José C. Mangual, and Caleb Pagán

Derris cuttings rooted well under mulch in the field.—In November 1945 an experiment was established to compare mulches of leaves of lemon grass (*Cymbopogon citratus* (DC.) Stapf), leaves of abacá (*Musa textilis* Nee), black roofing paper, and black roofing paper painted white, for the planting of cuttings of *Derris elliptica* directly in the field.

At the end of 8 months 86 percent of the cuttings planted under 6 inches of lemon grass mulch developed into good plants. In the other treatments survival was 74, 46, and 65 percent, respectively. In nursery beds with mulch, usually about 80 percent or less of the cuttings rooted. The abacá plots required additional leaves 3 times in order to maintain a good mulch, while the other treatments did not require additional mulching. Three weedings were made during the experimental period but they required relatively few man-hours in comparison with usual weeding operations. Soil temperatures 6 inches beneath the black roofing paper often were 8° to 10° F. higher than at the same depth beneath the white paper. Soil temperature beneath leafy mulches has been reported previously (*64, pp. 5–6*) as sometimes 16° lower than soil temperatures of check plots without mulch.

Mulching derris resulted in a higher yield of roots and rotenone.—In January 1945 an experiment was initiated to determine the effect of mulching on the growth and yield of *D. elliptica.* Mulches were applied at different depths on four plots in a randomized plot design as follows: (1) Sugarcane leaves, 6 inches deep, and (2) 12 inches deep; (3) lemon grass leaves, 6 inches deep, and (4) 12 inches deep; (5) derris debris (decomposed leaves and stems), 3 inches deep; and (6) 6 inches deep. The derris was harvested in January 1947. The average dry weights of the roots under each treatment, harvested 24 months after planting, are presented in table 1.

In all treatments the smallest quantity of roots was produced in the 0- to 4-mm. diameter class. With the exception of two instances the largest quantity of roots was in the 4- to 8-mm. class. There was little difference in the quantity of roots produced in the level and ridged check plots. In all cases the yield of roots was higher in the mulched than in the check plots. Plots mulched with 6 inches of derris debris averaged 110 percent more roots than the check plots; those mulched with 12 inches of sugarcane leaves produced 94 percent more roots, while plots mulched with 6 inches of lemon grass yielded 90 percent more roots than the checks. Mulched plots with 6 inches of sugarcane leaves produced 74 percent more roots. The mulches of sugarcane leaves and derris debris to some extent resulted in larger yield than those with shallow mulches with one exception, where plots with 12 inches of lemon grass mulch yielded less than plots with 6 inches.

TABLE 1.—*The average content of rotenone and yield of rotenone in derris roots produced under different mulches (25 plants)*

Treatment	Rotenone by plots				Average rotenone	Average total dry weight of roots	Yield of rotenone
	1	2	3	4			
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Grams*	*Grams*
Check, level	6.18	7.76	6.84	8.53	7.33	591	43.32
Check, ridged	7.70	6.32	7.81	6.80	7.18	637	45.74
Cane leaves 6 inches deep	7.20	7.86	7.04	7.26	7.34	1,070	78.54
Cane leaves 12 inches deep	7.62	6.90	6.38	7.83	7.18	1,191	85.51
Lemon grass 6 inches deep	7.51	8.97	6.89	7.97	7.84	1,167	91.49
Lemon grass 12 inches deep	7.86	7.56	7.35	7.54	7.58	805	61.02
Derris debris 3 inches deep	6.64	7.61	7.81	7.70	7.44	967	71.94
Derris debris 6 inches deep	6.82	6.21	6.05	6.16	6.31	1,291	81.46

No differences in the distribution of roots beneath mulched and check plots were observed. Practically all of the mulches in this, as with the first experiment, were decomposed by time of harvest. No difference was noted in the amount of labor required for harvesting the various plots.

With one exception there was no great difference between treatments in the average percentage of rotenone; derris debris 6 inches deep produced roots with only 6.31 percent rotenone, while the other treatments produced roots with 7.18 to 7.58 percent rotenone. Shallow mulches produced roots with a somewhat higher percentage of rotenone than did deep mulches. In all cases deep mulches produced a higher yield of rotenone than shallow mulches with one exception, where the 6-inch lemon grass mulch produced more rotenone than that at 12 inches.

It was concluded that the mulching of the Sarawak Creeping variety of *Derris elliptica* is a sound agricultural practice which reduces weeding costs and results in a higher yield of rotenone per acre (*66*).

LOSSES OF ROTENONE DURING STORAGE

By CALEB PAGÁN and RICHARD H. HAGEMAN

Powdered derris roots deteriorated when stored in paper bags.—In March 1945 a chemical evaluation of nine MG clones was reported

by Jones et al. (*32, pp. 89–93*) and the clones were ranked according to rotenone content.

As it has been shown by Pagán and Loustalot (*45*) that the rotenone content is not the best criterion of insecticidal activity in derris roots, it was considered desirable to make a preliminary toxicological comparison of these nine MG clones with guppies as the test animal (*43*).

The samples used for the tests had been stored in paper bags under laboratory conditions since the last chemical evaluation in 1945. During May 1947 a second chemical assay of the samples was made in order to determine whether there had been any decomposition in the root powder. The data obtained from these analyses showed some deterioration of the chemical constituents of the samples. In some cases the loss in rotenone content amounted to about 20 percent.

A root sample of clone MG No. 1 recently dug and analyzed was included in the test as a check. It is of interest to note that this sample was equal in rotenone but higher in red-color value and total extractives than the previous sample. The rotenone equivalent of the old sample as compared with the check showed some deterioration in insecticidal activity. For this reason, these data could not be used to rank the samples on the basis of their toxicological value. From these results it is evident that powdered derris roots stored in paper bags for long periods of time may lose up to 20 percent of their rotenone content and other toxic constituents, thus lowering their insecticidal potency.

The extracts of these samples, which were analyzed for transmittance (*44*), were discolored and gave abnormally high values. The discoloration and the high transmittance values are additional evidence that decomposition had occurred in the stored root.

RELATIVE TOXICITY OF ROTENONE PLANTS

By Caleb Pagán

A rapid method for biologically assaying derris and lonchocarpus roots was developed.—Chemical assays for rotenone content and red-color value are commonly used as criteria for the evaluation of the roots of derris and lonchocarpus. Such evaluations are not necessarily in close agreement with the toxicological value of the material (*31, pp. 7–8*). When insects such as houseflies or Mexican bean beetles are used as test animals, the biological method is time-consuming and expensive and, therefore, not well adapted to routine tests.

With the idea of developing a quick biological assay method, tropical fish, guppies (*Lebistes reticulatus* Peters), were tried as test animals for determining the toxicity of derris and lonchocarpus roots.

The guppies were chosen as test animals because (1) they were available in large numbers at no cost, (2) they could be obtained at uniform stages of development, and (3) they were easy to handle in the laboratory and required no special food or attention. The fish used in the tests were obtained from the ponds and ditches on the station grounds. The mean length of 150 adult male guppies was found to be 20.2 mm. with a standard deviation of 2.2 mm. and the mean weight of 121.1 mg. with a standard deviation of ±13.0 mg.

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Only adult male guppies were selected for the test in order to reduce variation in susceptibility due to sex and age. The selection of adult males was easily made because of their distinct coloring in contrast to that of the females and young males.

Two different methods of estimating toxicity were tried. The first method was essentially the same as the one described by Gersdorff (*19, pp. 881–891*) in which the speed of toxic action was used as a measure of toxicity. The main objection to this procedure was the fact that close and constant observation was necessary to determine the death point. This was particularly inconvenient at the lower concentrations in which several hours were required for the death point to be reached. Furthermore, the death point was somewhat difficult to determine exactly. The usefulness of this method was found to be limited and not adaptable for routine work particularly where large numbers of samples are involved.

In the second method the dosage mortality principle was used and found to be more convenient. The procedure followed in this method was to allow the fish to remain in contact with the toxic solutions for a definite length of time (6 hours was found to give the best results), after which the number of dead were counted.

In preliminary experiments it was found that mortality of the guppies was proportional to the concentration of rotenone when 1 ml. of acetone solution ranging from 0.025 to 0.2 mg. per milliliter was added to 1 liter of water in which 10 fish were swimming. The log of rotenone concentration plotted against mortality probits resulted in a straight line curve.

The test solutions of the root samples were prepared by extracting them with acetone and diluting the extract so that 1 ml. of acetone solution of each sample contained 0.025 mg. of rotenone. One milliliter of this solution was added to 1 liter of water and thoroughly mixed. The test solutions of rotenone standards were similarly prepared with rotenone at the following concentrations: 0.025, 0.0375, 0.0500, and 0.1000 mg. per milliliter of acetone. A control solution consisted of 1 liter of water to which 1 ml. of pure acetone was added.

Approximately 2 hours were required to set up the experiment, including the preparation of test solutions, and the randomization of the fish.

Soon after the fish were put in some of the test solutions several of them showed signs of poisoning and a few minutes later were dead. It was observed during the course of the experiment that fish swimming strong and to all appearances healthy would suddenly appear ill, turn on their sides, and die within a few minutes. This behavior was advantageous because when the final mortality counts were made the calculations were not complicated by moribund or visibly affected animals as is the case when houseflies and other insects are used as the test animal.

Mortality was computed at the end of 6, 24, and 48 hours. Of the total dead, 90 percent were killed in the first 6 hours. None of the fish in the control solutions were dead at the end of this period. Since there was no improvement in the results when the exposure time was extended to 24 and 48 hours, the mortality at 6 hours was taken as a basis for calculations.

The rotenone equivalent of the samples as determined on houseflies is included in table 2 for comparison with the rotenone equivalent

found with guppies. The agreement between the two sets of data is very close. The order of toxicity of the samples and the rank is similar in both cases. The actual values for rotenone equivalent determined on houseflies and guppies are in surprisingly close agreement when we consider the wide difference in technique and test animals. It is evident from these data that the toxicity of derris and lonchocarpus roots to guppies and houseflies is essentially the same for all practical purposes.

It has been shown that toxicological data obtained with houseflies are in good agreement with those obtained with Mexican bean beetles (*39*). In view of this fact it seems valid to substitute guppies as a test animal in the biological assay of derris and lonchocarpus roots.

The advantages of the guppies as test animals over houseflies and Mexican bean beetles are considerable. These are as follows: (1) Rearing of guppies, when required, is less troublesome than rearing insects or other fish. In tropical countries guppies can be caught easily in large quantities in ponds and ditches. (2) No special apparatus or technique is required. (3) Results are obtained within a relatively short time, usually within 1 day.

TABLE 2.—*The toxicity to guppies and houseflies of some derris and lonchocarpus roots*

Sample [1]	Rotenone	Weight root [2]	Mortality 6 hours [3]	S. E.	Rotenone equivalent [4]		
					Guppies		Houseflies [5]
					Test solution	Root [6]	Root
	Percent	*Mg./ml.*	*Percent*	*Percent*	*Mg./ml.*	*Percent*	*Percent*
Sarawak Creeping	5.4	0.46	44	7.5	0.0530	11.45	12.00
Changi No. 3, MG clones	7.3	.34	24	2.0	.0375	10.95	11.17
Sarawak Creeping (1) [1]	5.3	.47	20	5.5	.0345	7.30	7.72
Changi No. 3, P. R.	3.7	.68	22	6.7	.0355	5.26	5.67
St. Croix	1.8	1.39	46	6.8	.0550	3.95	4.24
L. nicou (1) [1]	4.7	.53	32	5.8	.0430	8.05	8.03
L. nicou	5.5	.46	16	4.0	.0315	6.92	7.69
L. chrysophyllus	5.7	.44	12	3.8	.0280	6.40	6.06
Rotenone standard	---	.025	8	3.8	---	---	
Rotenone standard	---	.0375	24	11.3	---	---	
Rotenone standard	---	.0500	38	7.4	---	---	
Rotenone standard	---	.1000	82	5.8	---	---	

[1] First 5 samples are varieties of *D. elliptica*. Sarawak Creeping (1) grown in Guatemala and *L. nicou* (1) in South America; the rest grown in Puerto Rico.

[2] Weight of root powder times percent rotenone gave desired concentration of rotenone in test solution, i. e. 0.025 mg./ml.

[3] Differences among mortalities greater than 17 percent are significant at odds of 19:1.

[4] Rotenone equivalent is the amount of rotenone the sample would need to contain in order to give the kill actually found.

[5] As determined in houseflies by W. A. Gersdorff and E. R. McGovran of the Bureau of Entomology and Plant Quarantine. Differences among the mean mortalities greater than 6 percent are significant at odds of 19:1.

[6] Rotenone equivalent in test solution divided by weight of root gives rotenone equivalent in root.

A toxic rotenoid was isolated from 3-months-old derris root.—A small amount of a toxic compound was isolated from young roots of *Derris elliptica*, MG clone No. 1. To separate this compound 90 grams of the powdered root were extracted with CCl_4 in a Soxhlet for 16 hours, which removed the rotenone plus a major portion of the rotenoids. This powder was then extracted for 8 hours with $CHCl_3$. The chloroform was removed with suction and replaced with ethyl

alcohol. The alcoholic solution was set aside in the refrigerator for about 2 weeks. At the end of this time several reddish crystals had precipitated. The substance was recrystallized from alcohol in small reddish crystals which formed aggregates resembling small spheres about 1 mm. in diameter. The melting point was found to be 115° C.

Preliminary chemical tests were made in order to identify the compound. The red-color test as modified by Jones (*26, pp. 352–359*) gave a positive reaction with the substance. The intensity of the red color was about 80 percent of that obtained with the equivalent weight of rotenone. The confirmation test developed by Jones (*27, pp. 127–129*) was tried next. In this method the red color is transferred into a chloroform layer if it is caused by a rotenone-type compound. The compound gave a positive reaction with this test also. The spectral transmittance curve of the compound was determined and found to have a maximum absorption at the same wavelength as rotenone (360 mμ). The red color of the compound has a second maximum absorption between 450 and 500 mμ but the curve is essentially that of a rotenoid. The toxicity of the compound compared to that of rotenone was determined on guppies (*43*). If the toxicity of rotenone is taken as 1.0, the compound has a value of 0.7. Attempts have been made without success to isolate this compound from Changi roots older than 3 months. This suggests that this substance may be a precursor of rotenone or of the rotenone-type compounds since it is found only in the young plant, disappearing as the plant grows older.

CHEMICAL INVESTIGATIONS

By Caleb Pagán, Arnaud J. Loustalot, and Richard H. Hageman

A simple, rapid method for estimating toxicity of derris root was devised.—The best criteria for determining the insecticidal value of *Derris elliptica* is the biological assay method. This method is expensive and time-consuming and, therefore, not adapted for use where large numbers of samples are involved, as in commercial assays or in a plant breeding and selection program. There is a definite need, therefore, for a simple, quick method of determining the toxicological value of derris roots.

The red-color value of the roots has been shown (*29, pp. 281–283*) to correlate more closely with the biological assay than any other chemical value, but it has certain limitations because of the fact that the values obtained are not always in close agreement with the biological assay.

The four main insecticidal constituents of derris root are rotenone, deguelin, elliptone, and toxicarol. It was found that acetone solutions of these compounds absorb light in the near ultraviolet with a maximum absorption in the neighborhood of 360 mμ. The maximum absorption of rotenone, deguelin, and elliptone occurred at a wavelength of 360 mμ. Although toxicarol absorbed strongly at 360 mμ, the wavelength of maximum absorption was near 400 mμ. A criterion for toxicity such as the transmittance value would be simple and rapid and would obviate the expensive and time-consuming biological assay.

Thirteen samples were available for experimentation, 8 of *Derris elliptica*, and 5 of *Lonchocarpus* (3 of *L. utilis* and 2 of *L. chrysophyllus* Kleinh.). These samples had previously been assayed biologically and

chemically by Jones et al. (*28, pp. 9–10*) and were used because the essential data were at hand.

The transmittance values of the eight derris samples when plotted against the toxicological value expressed as rotenone equivalent (determined on houseflies) correlated fairly closely with the biological estimation of toxicity. This applied to samples of derris only because when the five lonchocarpus samples were tested in a like manner the correlation between percent transmittance and rotenone equivalent was not close. Likewise, the red-color values of these lonchocarpus samples were widely divergent from their toxicity as determined biologically. This probably is an indication that some of the toxic constituents in lonchocarpus roots are different from those in derris roots. The details of the method have been published in the Journal of Agricultural Research (*44*).

Total chloroform extractives gave good indication of toxicological value of derris root.—The fact that special apparatus and technique are needed imposes certain limitations on the use of the transmittance method. The red-color value also has limitations because a spectrophotometer is needed and the conditions required for the test are rather exacting, and the results, as shown in the foregoing experiment, are not always in close agreement with the biological assays.

In order to obtain additional information for comparing the rotenone equivalent with the chemical values, the data previously used in the development of the transmittance method were analyzed statistically. In these statistical analyses the lonchocarpus and derris samples were treated separately because laboratory and field studies indicated that they have different chemical and toxicological properties.

The regression equation and the correlation coefficient between the biologically determined rotenone equivalent and the chemical values were calculated. Although all three correlation coefficients were highly significant, the values for total chloroform extractives and red-color value were much higher than that for rotenone, indicating that total chloroform extractives and red-color value are better criteria. The "T" values obtained indicated highly significant regression coefficients in all cases, but again the value for total chloroform extractives (10.19) and the red-color value (10.98) were both considerably higher than the value for rotenone (4.36). The standard errors of estimate calculated for the three analytical values show that the error in estimating toxicity from rotenone is about twice that from total chloroform extractives and red-color value.

When the regression lines between the rotenone equivalent of the derris samples and the rotenone content, red-color value, and total chloroform extractives, were plotted, the best agreement was obtained with total chloroform extractives, and the next best with red-color value.

This is additional evidence that at least with derris roots the rotenone content is not a dependable criterion of the insecticidal value of the roots (*45*).

There was no statistically significant correlation or regression between the rotenone equivalent and any of the constituents studied in lonchocarpus roots. The correlation and regression between rotenone and rotenone equivalent was almost negatively significant with a value of -0.832. For significance at the 5-percent level the correlation co-

efficient should be 0.878. Paradoxically, this indicated the rather startling fact that, in these lonchocarpus roots, the actual insecticidal value decreases as the rotenone content increases.

It is well established that rotenone is an efficient and versatile insecticide, but it is also apparent that it is only one of several constituents in derris roots capable of killing insects. The best criteria of toxicity would appear to be one which would measure not only rotenone but the other toxic constituents as well. The red-color value seems to correlate more closely with rotenone equivalent than rotenone content alone because it includes such rotenoid-type compounds as deguelin. However, since there may be other toxic substances in the root which do not give the red-color test, this criterion in some instances may not indicate the total toxicological value of the root. As pointed out previously, the red-color value has the added disadvantage, as has the transmittance value, of requiring a spectrophotometer and also rather exacting conditions. On the other hand, total chloroform extractives appear to be an accurate criterion of toxicity of derris roots. This is apparently due to the fact that all or almost all of the insecticidal constituents of derris roots are soluble in chloroform and, therefore, are readily extracted by this solvent. Since waxes, resin, and other plant material may dissolve in chloroform, it is not surprising that the value for total chloroform extractives as such is usually somewhat higher than that of the rotenone equivalent as determined biologically. However, from the correlation coefficient obtained it is apparent that the ratio of the nontoxic constituent of the derris root to the toxic constituents is fairly constant and thus the total chloroform extractives multiplied by the appropriate factor give a good indication of the insecticidal value of the roots. The factor calculated from the eight available derris samples was 0.78.

In the case of lonchocarpus root, neither the total chloroform extractives nor the red-color value appears to be a very good criterion of toxicity, whereas rotenone content, although it correlates negatively with toxicological value, seems to be more indicative. However, since the number of samples available for comparison is relatively small, this may not always be the case.

Although roots of both *Lonchocarpus* and *Derris* contain rotenone, they are two distinct genera and apparently have different toxicological effects on insects. The data presented strongly suggest that they should be evaluated separately.

Blendor speeds determination of total chloroform extractives.—The determination of total chloroform extractives has been suggested as a simple and reasonably accurate criteria of estimating the toxicological value of derris roots (*45*). The standard method for extracting derris root samples for total extractives and chemical analysis requires considerable time. The standard procedure used in this laboratory involves shaking the sample for 3 hours in a mechanical shaker, permitting it to stand overnight, and then giving it another hour of shaking. Preliminary tests with a Waring blendor showed that 5 minutes of blending was sufficient to give complete extraction.

A series of tests was made to compare extraction in the blendor with the standard method, using total chloroform extractives as the criterion for complete extraction. The procedure in both methods

was identical with the exception of the method of agitation. Twenty-four 30-gram samples of derris root were taken from a uniform composite sample and each mixed with 10 grams of Norite A and 300 cc. of chloroform and extracted by (1) standard method, and (2) blendor. Twelve replicate determinations were made by each method. After filtering to remove the marc a 10-cc. aliquot of the filtrate was evaporated to dryness, dried in the oven at 105° C. for 1 hour, and weighed to determine the total chloroform extractives.

The results obtained by the blendor method were essentially the same as those obtained by the standard method. The average value of the total chloroform extractives was 15.64 percent with a standard deviation of ±45 when the samples were extracted with the blendor. The standard method gave an average yield of 15.48 percent with a standard deviation of ±44. Rotenone determinations made from these extracts were almost identical. Samples extracted with the blendor gave an average yield of 5.70 percent with a standard deviation of 0.05 percent. The samples extracted by the standard procedure gave an average yield of 5.70 percent, with a standard deviation of 0.04 percent.

These results indicate that the blendor is as accurate in obtaining complete extraction as the standard method of extraction. In addition to the same degree of accuracy, the time of extraction is shortened from several hours to 5 minutes.

STATISTICAL INVESTIGATIONS

By Caleb Pagán and David G. White

Rotenone content of derris roots can be determined from total chloroform extractives.—In the course of analyzing hundreds of derris samples in connection with agronomic experiments, it was observed that there was a fairly close relationship between the percentage of total chloroform extractives and the rotenone content. To establish this fact statistically a critical evaluation of data from three experiments was made with respect to rotenone content, rotenone plus rotenoids, and total chloroform extractives of roots from different varieties of *D. elliptica* and of *L. utilis* (*46*).

The data were expressed on a percentage dry-weight basis, and the ratios of rotenone to rotenone plus rotenoids and of rotenone to total chloroform extractives were calculated. The ratios were analyzed statistically to establish the standard deviations from the means and the correlation coefficients.

The results indicated that the ratio of rotenone to rotenone plus rotenoids or to total chloroform extractives was reasonably constant among varieties, although the least deviation as would be expected, occurred within a variety. Within the Sarawak Creeping variety there were small deviations from the mean ratios of roots harvested at 14 and 32 months. In all cases there was a highly significant correlation between rotenone and rotenone plus rotenoids and between rotenone and total extractives. In 8 out of 10 cases the correlation coefficient between rotenone and total extractives was higher than between rotenone and rotenone plus rotenoids.

Samples of roots of *Lonchocarpus utilis* selected at random from

wild plants grown in Peru were similarly analyzed.[3] In 50 sample plants the mean ratio of rotenone plus rotenoids was found to be 0.447 ± 0.039, with a correlation coefficient of 0.944. The mean ratio of rotenone to total extractives was found to be 0.364 ± 0.024, with a correlation coefficient of 0.967, a higher correlation than for the first ratio.

Cuttings from the MG Changi clones (*42, pp. 4–5*) were propagated in the field for use in an agronomic experiment. After 2 years the roots were excavated, washed, and air-dried. Analyses were made for rotenone and total chloroform extractives. The differences in rotenone content between the actual and calculated values were not excessive and for practical purposes, such as a plant selection program, the calculated percent rotenone may be used.

These results indicate that determination of rotenone for individual samples is not necessary where large numbers are involved. Duplicate analyses for rotenone in a composite sample should be made together with total chloroform extractives and a ratio established. The rotenone content of individual samples can then be estimated by multiplying the percentage of total chloroform extractives by the ratio. Determination of total chloroform extractives in each sample appears to be the easiest and quickest method for evaluating large numbers of samples for rotenone content with reasonable accuracy.

PLANT TOXICOLOGICAL STUDIES

LABORATORY TESTS

By Harold K. Plank

Twelve of 26 species of plants were somewhat toxic to certain insects.—Twenty-six species of plants established in Puerto Rico were examined during the year for insecticidal properties. Powdered samples of the seeds, leaves, bark, stem, and roots were tested in the laboratory against larvae and adults of five species of common insects belonging to four different orders. The methods employed were similar to those outlined in previous reports and designed to show insecticidal activity, if present, under conditions most favorable to the plant material (*52, pp. 11–13*).

The species of plants tested were the following: *Abrus precatorius* L.; *Albizzia lebbeck* (L.) Benth.; *A. stipulata* (Roxb.) Bois.; *Antonia ovata* Pohl, P. I. 106371; *Calophyllum antillanum* (Griseb.) Britton; *C. inophyllum* L.; *Calotropis procera* (Ait.) R. Br.; *Carapa guianensis* Aubl.; *Cassia nodosa* Hamilt.; *Cinchona ledgeriana* Moens; *Cyperus rotundus* L.; *Entada polystachya* (L.) DC.; *Erythrina* sp., P. I. 109849; *E. variegata orientalis* (L.) Merr., M. 2663; *Euphorbia heterophylla* L.; *Jacquinia* sp., M. 2702; *Leonotis nepetaefolia* (L.) R. Br.; *Petiveria alliacea* L.; *Phyllanthus acuminatus* Vahl., P. I. 106936; *Piper betle* L., M. 4703; *Piscidia acuminata* (Blake) I. M. Johnst., P. I. 106018; *Quassia amara* L., P. I. 107001; *Ruprechtia* sp., P. I. 109868; *Sapindus* sp., P. I. 107834; *Triplaris surinamensis* Cham., P. I. 108263; and undetermined, P. Q. 032589.

One or more parts of 12 of the foregoing plants showed moderate insecticidal activity and some were appreciably toxic to at least one of

[3] Plants collected by E. C. Higbee, Office of Foreign Agricultural Relations.

the test insects used. The results secured with these parts are summarized in table 3.

TABLE 3.—*Results of laboratory tests for insecticidal activity of the most toxic parts of some locally established plants*

Plant and part	Toxicity to—					
	Diaphania hyalinata, larvae, in 2 days	*Plutella maculipennis*, larvae, in 2 days	*Cerotoma ruficornis*, adults, in 2 days	*Dysdercus sanguinarius*, adults, in 2 days	*Periplaneta australasiae*, last-stage nymphs, in—	
					2 days	2 weeks
Albizzia lebbeck:	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Petioles	10.0	----------	0	45.5	0	0
Calotropis procera:						
Roots	42.9	16.0	0	16.0	12.0	32.0
Cassia nodosa:						
Roots	41.7	60.0	0	6.7	4.0	13.1
Cinchona ledgeriana from Maricao:						
Bark	[1] 63.6	32.0	0	0	0	0
C. ledgeriana from Toro Negro:						
Bark	52.2	32.0	4.0	0	0	0
Wood	50.0	36.0	8.0	0	0	0
Roots	[1] 59.1	40.0	0	0	8.0	0
Jacquinia sp., M. 2702:						
Roots	52.6	88.0	8.0	29.4	0	0
Leonotis nepetaefolia:						
Ripening seed heads	[1] 68.2	8.0	36.0	21.0	0	0
Leaves	[1] 54.5	0	0	0	0	0
Phyllanthus acuminatus, P. I. 106936:						
Bark	29.2	8.0	20.0	46.7	0	0
Roots	41.7	0	4.0	13.3	0	4.4
Piper betle, M. 4703:						
Leaves	50.0	----------	12.0	5.3	0	0
Roots	29.2	----------	56.0	23.3	0	0
Piscidia acuminata, P. I. 106018:						
Leaves	68.0	60.0	0	4.0	0	0
Roots	75.0	76.0	0	11.8	0	0
Quassia amara, P. I. 107001:						
Roots	50.0	44.0	32.0	17.7	4.0	16.0
Triplaris surinamensis, P. I. 108263:						
Leaves	10.5	0	0	43.5	0	0

[1] Average of two tests.

Worthy of note in table 3 is the fact that bark of *Cinchona ledgeriana* from the station planting at Maricao, the ripening seed heads of *Leonotis nepetaefolia*, and the leaves and roots of *Piscidia acuminata* were appreciably (more than 60 percent) toxic to larvae of *Diaphania hyalinata* (L.). However, except for *P. acuminata* roots, which also were moderately to appreciably toxic to larvae of *Plutella maculipennis* (Curt.), none of these parts was more than weakly toxic to any of the four other species of insects used. The results with *L. nepetaefolia* are in line with a previous report on this plant by Asenjo (*6*). The roots of *Jacquinia* sp., besides being moderately toxic to *Diaphania* larvae, were also appreciably active against larvae of *P. maculipennis*. *C. ledgeriana* bark from the station planting at Toro Negro was only moderately toxic to *Diaphania* larvae as were also the wood and roots. In this same category were the remaining samples in table 3. With the exception of the roots of *Cassia nodosa*, all seemed to affect only one test insect. Most were inert to the nymphs of *Periplaneta australasiae* (F.).

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The other samples examined were either inert or at most weakly toxic to all the species of insects used in these tests. Among these weakly toxic materials were the tops, leaves, and tubers of *Cyperus rotundus*. A contact insecticide "effective against grasshoppers and other insects" (*1, p. 351*) is reported to be made from this plant in Costa Rica.

Mamey controlled fleas and ticks on dogs.—The powdered mature seeds of mamey (*Mammea americana* L.) and a water infusion of the half-ripe fruits (*52, pp. 11–13*) were retested on dogs in comparison with DDT for the control of fleas, mostly *Ctenocethalides felis* (Bouché), and the brown dog tick (*Rhipicephus sanguineus* (Latr.)). In two experiments each material was applied to separate lots of three dogs each. The seed powder was rubbed well into the hair; the infusion of 1 pound of a half-ripe mamey fruit in 1 gallon of water and a 1-percent suspension of DDT in water were used as dips.

All dogs were free of fleas within 24 hours and of ticks within 3 days after treatment. On fleas the effect of both forms of mamey was immediate, the majority being at least partially paralyzed in 15 minutes and dead within half an hour. DDT did not appear to act so quickly; most of the fleas under this treatment dropped from their hosts and many were still alive at the end of this time, although unable to move normally. On ticks no difference in speed of action was noted.

Liberated 6 hours after treatment, the mamey-treated dogs became reinfested with fleas in from 3 to 7 days; those treated with DDT remained free for from 6 to 13 days. One of the mamey-treated dogs became reinfested with ticks within a week after liberation, but the remainder, including those treated with DDT, were uninfested for 2 weeks.

No effort was made to keep any of these materials from the eyes or mouths of the dogs, and one or more dogs in each lot had healing sores or minor abrasions of the skin. Although none of the dogs treated with mamey was observed to lick itself after treatment, two of those treated with DDT did so on numerous occasions. Nevertheless, no treatment appeared at any time to have any deleterious effect on the health or behavior of any of the dogs. The mamey treatment tended to color the coat of the white-haired dogs a light brownish yellow, whereas the DDT suspension gave dark-haired dogs a grayish-white appearance. However, neither discoloration was objectionable and both gradually disappeared until they were hardly noticeable at the end of 2 weeks.

In the foregoing experiments both forms of mamey seemed to act faster and be as effective though not quite so permanent as a 1-percent suspension of DDT in the control of fleas and ticks on dogs. The mamey-fruit infusion offers a cheap and readily available means of controlling these two common pests of dogs in Puerto Rico and other tropical areas.

FIELD TESTS

By Harold K. Plank and Pedro Seguinot Robles

Mamey was less effective than DDT in field control of insects on soybeans.—Field tests have indicated that mamey may have some value in the control of certain insects on a limited number of plants (*49, p. 738; 50, pp. 23–24*). A further trial of this material under field

conditions was made in comparison with DDT against insects on soybeans. The powdered mature seeds, the only form available at the time, were used at the rate of 8 pounds in 100 gallons of water; DDT was used at 4 pounds of the 25-percent wettable-powder form in 100 gallons of water. To both materials was added 8 fluid ounces of a commercial spreader-sticker in each 100 gallons to increase wetting power.

One application of each material was made on October 24, just following full bloom and the setting of some pods on most of the plants in an area of 0.156 acre planted on August 30 with the Seminole variety of soybeans. The field was divided into 9 plots of 7 rows each, spaced 3 feet apart, to provide 3 replicates for each treatment plus the check. Of the mamey spray 309 gallons per acre were used and of the DDT 265 gallons. Analyses showed a deposit of 0.115 mg. of DDT per square centimeter of leaf area 2 hours after application and none at the end of 10 days.[4] In the interim a total of 0.32 inch of rain had fallen during a total of 3 days. The first of these 3 rainy days (the fourth day after application) had the maximum precipitation of 0.26 inch. Residue from both suspensions was plainly visible on the leaves for 3 weeks after application. Neither spray appeared to have any toxic effect on the plants at any time.

Most of the usual soybean pests were present on the test plants, but their population was low throughout the trial. There was scarcely any difference in appearance among the various plots that could be attributed to insect control and, statistically, there were no significant differences in the yields of dry beans when harvested on November 26. However, immediately after treatment there was a noticeable decrease in the numbers of leaf beetles and leafhoppers and of leaftier infestations that could be observed in the plots sprayed with DDT and to a somewhat less extent in those sprayed with mamey. More definite information concerning the effect of the treatments on these and other insects, as secured from examinations of leaf samples taken immediately before spraying and at 10 and 20 days thereafter, may be summarized as follows:

The numbers of leafhopper nymphs present, a maximum of 7 per 30 leaves, were too small to show any significant differences between the treatments and the check. On adults and nymphs of *Hercothrips phaseoli* (Hood) and of two species of *Echinothrips*[5] mamey produced a slight but statistically insignificant reduction toward the end of the experiment. The effect of DDT, however, was immediate and lasting, the sample leaves being entirely free of all stages of thrips beginning 10 days after treatment. Infestation by the cotton aphid (*Aphis gossypii* Glov.)[6] was particularly heavy on the check plots, where 70 percent of the leaves were attacked and some curling took place. Mamey, with a final infestation of 77 percent, failed to effect any control. DDT kept the aphis infestation at less than 30 percent throughout the experiment.

Although there was considerable evidence of feeding by the leaf beetle, *Cerotoma ruficornis* (Oliv.), and somewhat less by the flea-beetle, *Systena basalis* J. Duval, both species seemed to be little affected

[4] These analyses were made by Caleb Pagán Carlo, chemist.
[5] Determined by J. C. Crawford, Bureau of Entomology and Plant Quarantine.
[6] Determined by P. W. Mason, Bureau of Entomology and Plant Quarantine.

by either mamey or DDT. Mamey controlled feeding to the extent of only 12 percent and DDT 24 percent, neither being statistically significant. Mites of two species of *Tetranychus* near *bimaculatus* Harvey [7] were present, and there was a highly significant increase in the percentage of leaves infested by them in the plots sprayed with DDT over that in the mamey and check plots. Counts of the number of leaves tied together by *Hedylepta indicata* (F.) and other pyraustids of similar habit showed no significant difference between mamey and the check at any time, but the difference between DDT and the check was highly significant at all times. At 20 days after spraying, control of leaf tiers was 20 percent by mamey, and 80 percent by DDT.

The pineapple mealybug (*Pseudococcus brevipes* (Ckll.)), reported previously as an important pest of soybeans (*48, p. 13*), was found infesting the crown of about two-thirds of the untreated plants in this experiment. All colonies were attended by the fire ant (*Solenopsis geminata* (F.)), one of the commonest and most prolific disseminators of this pest in Puerto Rico (*55, p. 60*). Twenty days after spraying, the reduction in mealybug infestation by mamey was not statistically significant but that by DDT was significant. Some of the plants examined in the mamey plots and all of those in the DDT plots bore only small colonies of mealybugs and these were attended by few ants. In the untreated plots, on the other hand, the mealybug colonies were large and extended well above ground and the many ants in attendance had carried soil up over them. In a previous experiment with soybeans a reduction in mealybug infestation, somewhat similar to that produced by DDT, followed control of the attendant ants by other means (*48, p. 14*). DDT has already been observed to control a number of species of ants including *S. geminata* (*53*). In the present instance, much of the control of mealybugs by DDT was no doubt brought about through the control of the attendant ants during the first few days after application, while there was still an appreciable deposit of this material on the plants.

Under the conditions of the foregoing test it is apparent that the powdered mature seeds of mamey were ineffective in the field control of many insects on soybeans, but that DDT was very effective against thrips and leafhoppers and moderately effective against aphids, leaf tiers, and the pineapple mealybug. DDT greatly increased rather than decreased infestation by mites.

DRUG-CROP INVESTIGATIONS

CINCHONA PROPAGATION

By Harold F. Winters

Survival of initial field plantings varied widely.—Final transplantings of the 30 special strains of nursery-grown cinchona seedlings to the field were made at the Toro Negro plantation in October and November of 1946. These plants were grown from seeds collected in the Philippine Islands by Col. Arthur F. Fischer (*22, p. 28; 68, p. 14*). Table 4 gives the strain, the plant introduction numbers, and the percentage survival in June 1945 and August 1946. The number

[7] Determined by E. A. McGregor, Bureau of Entomology and Plant Quarantine.

TABLE 4.—*Summary of Cinchona field plantings at Toro Negro*

Plant introduction number	Species [1]	Date planted	Number planted	Survival					Number planted, November 1946
				June 1, 1945		1946			
				Number	*Percent*		*Number*	*Percent*	
	Cinchona ledgeriana Moens, progeny of 6 trees in Maricao planting.	August–November 1944	1,523	1,372	90.1			[2] 75.0	
	C. ledgeriana, Guatemala, Coban	November–December 1944	1,384	1,060	76.6	September	600	43.4	
P. I. 143981	*C. ledgeriana*	September–October 1944, November 1945.	2,202	735	33.0	do	430	19.5	80
	C. sp. (mostly hybrids) Castañer	October–November 1944	898	816	90.1	do	691	76.9	
	C. pubescens Vahl, Guatemala	August 1943	100	22	22.0			[2] 20.0	
	C. ledgeriana, Maricao progeny	August–October 1943	1,500	295	19.7			[2] 15.0	
P. I. 144071	*C. ledgeriana*	November 1945	48			August 30	41	85.4	80
P. I. 144073	*C. officinalis* L., No. 45	do	28			do	23	82.1	22
P. I. 144076	*C. officinalis*, No. 2	do				do			10
P. I. 144079	*C. pubescens*, No. 22	do	8			do	5	62.5	1
P. I. 144080	*C. pubescens*, No. 22	do	182			do	165	90.6	48
P. I. 144081	*C.* sp., C. S. X–1, S. Brazil	do				do			68
P. I. 144082	*C.* sp., C. S. X–2, S. Brazil	do	47			do	43	91.4	58
P. I. 144083	*C.* sp., C. S. X–3, S. Brazil	do	94			do	79	84.0	131
P. I. 144084	*C.* hybrid No. 9	do	87			do	77	88.5	48
P. I. 144085	*C.* hybrid No. 11	do	93			do	89	95.6	56
P. I. 144086	*C.* hybrid No. 147. Brazil	do	25			do	23	92.0	24
P. I. 144093	*C. ledgeriana*	do	20			do	13	65.0	2
P. I. 144094	*C. ledgeriana*	do				do			3
P. I. 144095	*C. ledgeriana*	do	100			do	57	57.0	8
P. I. 144096	*C. ledgeriana*	do	56			do	41	73.2	49
P. I. 144097	*C. ledgeriana*	do	25			do	17	68.0	
P. I. 144098	*C. ledgeriana*	do	11			do	10	90.9	
P. I. 144099	*C. ledgeriana*	do	15			do	12	80.0	39
P. I. 144100	*C. ledgeriana*	do				do			2
P. I. 144103	*C. pubescens* X–1	do				do			30
P. I. 144105	*C. pubescens* X–3	do				do			8
P. I. 144106	*C.* hybrid, Kaatoan Coll.	do	109			do	87	79.8	12
P. I. 144107	*C.* hybrid Impalatao	do	32			do	32	100.0	21
P. I. 144108	*C.* hybrid No. 1	do	15			do	11	73.3	7
P. I. 144109	*Cinchona* hybrid No. 2	do							7
P. I. 144110	*C.* hybrid No. 3	do	45			Aug. 30	40	88.8	34
P. I. 144111	*C.* hybrid No. 10	do	4			do	4	100.0	
P. I. 144112	*C.* hybrid No. 11	do	14			do	10	71.4	
P. I. 144113	*C.* hybrid No. 168	do	57			do	53	92.9	12
P. I. 144114	*C.* hybrid X–2	do	14			do	8	57.1	7
P. I. 148115	*C.* sp., Peru	do	484			do	403	83.2	310
Unidentified		do	127			do	118	92.9	

[1] The systematic position of *Cinchona ledgeriana* Moens is uncertain; most likely it is conspecific (perhaps a variety of *C. officinalis* L.) but this matter has not been settled.
[2] Estimated.

of each strain planted in November 1946 is also shown. Additional plantings were continued with seedlings of local strains and others from Peru and Guatemala.

Survival in 1946 varied from 15 to 100 percent. Usually the strains that survived well grew well and were generally healthier and more vigorous than the poorly surviving strains.

Bottom heat failed to induce rooting in Cinchona ledgeriana cuttings.—In a previous report (*68, pp. 16–17*) it was shown that cuttings taken from mature trees of *C. ledgeriana* rooted poorly if at all. However, fair results were obtained in rooting leafy cuttings taken from nursery seedlings. As a rule, cuttings from young trees rooted better than those from old trees. Results are reported here of additional trials with rooting of cuttings from mature trees with the application of bottom heat to the propagation medium.

For these trials a small propagation case 3 feet × 6 feet was erected at Maricao. A glazed sash of the same size served as a hinged lid. Expanded mica was used as a rooting medium which provided great water-holding capacity and good aeration. One-half the bed was maintained at 5° F. to 8° F. higher than the other half by a thermostacially controlled electrical resistance cable embedded in the mica.

The cuttings for these rooting trials were all growing branch tips taken from 15-year-old trees of *Cinchona ledgeriana* at Maricao. Twelve replications of 10 cuttings each were planted in each half of the bed. In addition, one-half (six) of the replications in each heated and unheated plot were treated with indolebutyric acid at a concentration of 2 mg. per milliliter of 50 percent ethyl alcohol by dipping the basal end in the solution prior to planting. Also, controls of 10 tip cuttings of *C. pubescens* were placed in each subtreatment since cuttings of this species root readily.

The cuttings were examined at 30, 60, and 90 days after planting. None of the cuttings of *Cinchona ledgeriana* rooted. Forty percent of the *C. pubescens* rooted when given both bottom heat and the hormone treatment.

Treatment of cinchona cuttings with Fermate did not increase rooting.—At the Toro Negro nursery the application of Fermate (70 percent ferric dimethyldithiocarbamate) to the sand rooting medium was not effective in increasing the percentage of rooted cuttings. In previous trials some cuttings have rotted without forming roots. The object of this experiment was to find a means of maintaining the cuttings in healthy condition until roots could be formed.

Fermate was mixed into the sand surface at the rate of 1 ounce per square yard before planting; the control plot was untreated. Each plot was divided into subplots for hormone treatment, and 38 cuttings were planted in each treatment. The basal ends of one-half the cuttings were dipped in a solution containing 2 mg. indolebutyric acid per cubic centimeter of 50 percent ethyl alcohol. Cuttings were taken from 1-year seedlings of *Cinchona ledgeriana.*

The application of Fermate to the soil did not increase survival of cuttings. Rooting was 89 percent in the Fermate plus hormone treatment, 65 percent with Fermate alone, 89 percent in untreated sand plus hormone, and 63 percent in untreated sand alone. The indolebutyric acid treatment significantly increased the percentage of rooting in both groups of cuttings.

The use of sand compared favorably with expanded mica as a rooting medium.—In another trial washed granitic sand was compared with expanded mica as a rooting medium. Adjoining plots in the propagation shed were filled with the two materials and a subdivision was made in each plot for treatment of cuttings with growth-promoting substances. In this instance a basal dip of naphthaleneacetic acid at a concentration of 2 mg. per milliliter of 50 percent ethyl alcohol was used. The cutting material for this trial was taken at transplanting time from a group of *Cinchona hybrida* plants. Twenty-six cuttings were placed in each subplot on November 7, 1946.

Under the conditions of this experiment a slightly higher percentage (about 10 percent) of the cuttings rooted in sand than in expanded mica. The effect of growth-promoting substance on rooting was not statistically significant.

Large size Cinchona seedlings were best for transplanting.—In August 1944 an experiment was initiated to compare cinchona seedlings of different sizes in the same age group for adaptability to field planting, and to compare the effect of different methods of pruning in preparation for transplanting on subsequent survival and growth in the field. The seedlings were divided into two size groups, large (21–36 inches in height) and small (8–20 inches). Large size seedlings were pruned at transplanting as follows: (1) Partial defoliation, removal of the apical one-half of each leaf; (2) removal of the upper one-third of each plant with pruning shears; (3) complete defoliation, all leaves removed except the expanding pair at the growing point; (4) control, without pruning or removal of leaves; and (5) removal of the upper one-third of each plant plus removal of apical one-half of the remaining leaves. For the small plants the following treatments were repeated: (1) Complete defoliation, (2) control, and (3) partial defoliation. Each plot consisted of 10 trees and treatments were replicated 6 times in a randomized block design.

Nine months after the seedlings were transplanted to the field, data were taken on survival and growth as measured by height. One year later final observations were made. A summary of these data is given in table 5.

TABLE 5.—*Survival and height of cinchona seedlings that received various pruning treatments before transplanting*

Treatment		Average survival		Average height				
Size group	Pruning	9 mo.	21 mo.	Before transplanting	9 mo.	Increase at 9 mo.	21 mo.	Increase at 21 mo.
		Percent	*Percent*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Large plants	Partial defoliation, ½ of each leaf removed	95.0	58.3	23.7	27.6	3.9	69.8	46.3
	⅓ top removed	93.3	76.7	23.7	22.4	—1.3	53.8	29.5
	Complete defoliation	86.6	60.0	27.5	27.3	—.2	56.9	30.5
	No treatment—check	90.0	61.7	26.3	24.6	—1.7	59.0	31.9
	⅓ top removed and partial defoliation	95.0	73.3	27.3	23.0	—4.3	59.3	30.9
Small plants	Complete defoliation	93.3	43.3	12.0	16.3	4.3	46.6	34.3
	No treatment—check	86.6	33.3	11.5	14.5	3.0	29.0	17.3
	Partial defoliation, ½ of each leaf removed	91.7	53.3	12.5	17.4	4.9	55.0	42.5

At the end of 9 months, average survival varied between 86.6 and 95.0 percent with no significant statistical difference between treatments. Plants in three treatments had not regained their original height; this could be attributed to the pruning treatment in plots where tops of the plants had been removed. In the controls it could be attributed to the fact that the plants were set a little deeper in the field than they had previously grown in the nurseries and to slow recovery after transplanting. The greatest increase in growth was obtained from the three treatments on small plants and by partial defoliation of large plants. However, all treatments of large plants resulted in better growth on the average than treatments of small plants. After 21 months average survival was better with all treatments of the large plants than with any of the small plants. Survival was significantly better where the tops of the large plants were removed than in any of the treatments with small plants. The partially defoliated large plants were tallest, averaging 69.8 inches, but poorest in survival within this size group. This treatment was not significantly better in growth than other treatments of large plants but was significantly better than complete defoliation and the small-plant controls.

It is interesting to note that growth was especially rapid in partially defoliated small seedlings, and at 21 months these plants had almost reached the average height of tall plants. Since survival in this treatment was also best within the small plant group, performance was attributed to treatment. It seems likely that growth of the small seedlings will soon equal that of large seedlings, but survival will be low.

From these results it appears that better survival can be expected in field plantings where only the large cinchona seedlings are planted. Such plants are stronger and more resistant to disease than the small plants. In the establishment of a plantation, survival is a most important consideration. Among the large plants, survival was best where one-third of the tops was removed. This is a standard practice in transplanting broad-leaved trees and shrubs as it brings the transpiration area of the top into balance with the root system. It should be pointed out that the trees with the tops removed were not significantly inferior in height to those in the other treatments at the end of 21 months. When small plants are to be used in a field planting, they should be partially defoliated.

Soil fumigation was of no apparent value in planting Cinchona.—During the past year an experiment was conducted at Toro Negro to determine the value of soil fumigation prior to transplanting cinchona seedlings to the field. In a previous experiment chloropicrin treatment improved survival and growth in cinchona nurseries (*68, pp. 17–18*). In the current field experiment this chemical was compared with formaldehyde and untreated plots.

Survival counts were made 2 months, 6 months, and 1 year after planting to the field. At the end of the year the lowest average survival, 50.8 percent, was in the chloropicrin treatment. Best survival was 52.8 percent, which was in the formaldehyde treatment, but the differences were not significant. A count was also made of vigorously growing plants but the differences between treatments were negligible.

From the results of this experiment it was apparent that fumigation of the individual planting sites with chloropicrin or formaldehyde had no effect on survival or growth of new field plantings of cinchona.

Mulching proved detrimental to young Cinchona field plantings.—An experiment was started in January 1945 to study the effect of mulching on growth of young cinchona field plantings. A hillside field of *C. ledgeriana* which had been planted the previous November was utilized for the experiment. There were four replications of the following treatments: (1) Mulched, chopped dead palm leaves scattered over soil at 2- to 3-inch depths; (2) mulched, plus fertilizer, palm leaf mulch as in (1) plus 2.5 pounds 6–9–10 fertilizer scattered over the plot; (3) no mulch, weeded when necessary; and (4) no mulch, weeded plus 2.5 pounds 6–9–10 fertilizer per plot. Each plot was about 10 by 15 feet in size and contained 20 trees.

The cinchona seedlings were planted during the rainy reason and the treatments were applied at the beginning of the following dry season. Survival and growth of all plants were generally poor at the particular site of this experiment. This was also noticeable in the border plants and in an adjoining experiment. The unfavorable exposure and soil of the site was probably responsible for the unsatisfactory results. In spite of the over-all poor survival a definite trend was noticeable. At the end of the first year average survival per treatment was as follows: (1) Mulched, 30.0 percent; (2) mulched plus fertilizer, 33.7 percent; (3) unmulched, 41.2 percent; and (4) unmulched plus fertilizer, 55.0 percent.

These results indicate that mulching has a detrimental effect on survival of newly planted cinchona; this may be due to an aggravated excess-soil-moisture situation. It is also indicated that fertilizer had a beneficial effect on survival.

Tropical kudzu made superior ground cover for Cinchona.—The first year of investigations at Toro Negro showed that certain species of cover crops were far superior to others in cinchona plantations. A search for suitable cover crops was started after witnessing the erosion which occurred during one season under clean cultivation. Leguminous cover crops have been used extensively in rubber plantations and are reported to have been used successfully in cinchona plantations in Java (*7, pp. 311–317*).

Little information is available in Puerto Rico on cover crops for high elevations under conditions of high rainfall. In the early summer of 1945 a collection of leguminous species was planted at the Toro Negro substation. Some of these were recommended cover crops for coastal areas and others were untried recent introductions. Test plots one-fortieth of an acre in size were planted where sufficient seed was available, otherwise a few 30-foot rows were planted.

Three species have made exceptionally heavy cover, namely *Pueraria phaseoloides* (Roxb.) Benth. or tropical kudzu, *Indigofera endacaphylla* Jacq. or trailing indigo, and *Desmodium uncinatum* (Jacq.) Kuntze. The first two suffered damage from a stem rot during the first rainy season. Tropical kudzu recovered the second year, but trailing indigo still has large dead areas. Tropical kudzu required nearly a year to become well established at Toro Negro, whereas at Mayaguez a good stand is usually obtained within 6 months. A

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mat of vines and foliage has formed about 1½ feet in depth, but this is somewhat less dense than that of the trailing indigo. This may be an advantage since the large leaves afford complete protection to the soil surface from sun and rain yet allow some aeration at the soil level.

Desmodium uncinatum (Jacq.) DC., a native of South America, shows considerable promise. It is a procumbent perennial vine with densely pubescent trifoliate leaves and stems. Leaflets are about 1½ by 2 inches in size. Flowering has been profuse during the winter months but scarcely any seed has been produced. Trials have shown that this plant can be propagated readily during the rainy season by 1-foot stem cuttings. From the two original 30-foot rows where the seed was planted, it has spread in 2 years to cover an area of approximately 20 by 40 feet. Without twining it stands at 2 to 2½ feet in height.

Desmodium nicaraguense Oerst., *Tephrosia candida* (Roxb.) DC., and a native shrubby *Indigofera* sp. have grown well. Since all are shrubby or leggy they may be of value for temporary shade or for retaining terraces. All are readily propagated from seed.

The dwarf bucare (*Erythrina berteroana* Urban) has also been found valuable for retaining terraces. In addition it has the advantage of being easily propagated by cuttings.

Several of the cover crops tested were apparently annuals because they died after one season at Toro Negro; all of them flowered and produced seeds. Two *Crotalaria* species only partially reseeded themselves. *Dolichos lablab* L. and *Stizolobium deeringianum* Bort. showed little, if any, reseeding. All of the annual species may prove impractical as cover crops for cinchona because of the extra labor involved each season in preparing the ground and planting. Also, they have the additional disadvantage of not providing complete cover throughout the year. The shrubby types probably will not be adapted for ground cover but many prove of value for temporary shade or for retaining terraces.

Cover crops failed to improve cinchona growth rate.—In addition to the above trial plots, the following species were planted among young cinchona trees in the plantation using one-fortieth acre plots in randomized block design: (1) *Crotalaria spectabilis* Roth., replaced the second season by *C. usaramoensis* Baker f.; (2) *Centrosema plumieri* (Turp.) Benth., replaced the second season by *Dolichos hosei* Craib; (3) *Pueraria phaseoloides;* and (4) natural vegetation. The plots of natural vegetation were included in the experiment as a check. They consisted mostly of grasses, ferns, and herbaceous plants of the Compositae and Commelinaceae families. There were few leguminous plants in these plots.

It was necessary to replant the *Crotalaria usaramoensis* several times, and one replication out of the four still does not have a complete stand. The steep terrain and washing rains appear detrimental to this crop. The upright habit of growth and sparse foliage do not provide adequate protection to the soil surface in regions of high rainfall.

The *Dolichos hosei* plots were planted from vine cuttings. Although survival was high, this legume has been slow in establishing a complete ground cover. After 1 year the ground is fairly well covered to a depth of 4 to 6 inches. Frequent weedings have been necessary to eliminate tall weed growth.

Growth of the tropical kudzu (*Pueraria phaseoloides*) (*59*) was more rapid than any of the other legumes. Within 1 year the long runners had completely covered the soil surface, and after 2 years the mat of vegetation is about 1 foot deep. At Mayaguez near sea level only 1 year is usually required for as much growth. The kudzu responded favorably to an application of complete fertilizer applied to the cinchona at the rate of one-fourth pound per tree. The vines tended to choke out competing growth so that less weeding of this species was necessary. However, the runners had to be cut from the young cinchona trees about once in 2 weeks.

During the fall rainy season of 1946 spots of a fungus disease developed in the tropical kudzu planting which were sometimes 3 feet in diameter. At first the foliage was observed to wilt. Upon examination it was found that the mat of leafless stems below the foliage contained many brown or black stems. In addition, some were covered with a white mycelial growth somewhat resembling an *Armillaria*. During the dry season these spots became bare, but were again covered with vines after the spring rains. The disease is not considered serious enough to discourage the planting of tropical kudzu at higher elevations in Puerto Rico.

At the end of the first and second years, height measurements were made of the cinchona trees growing in the cover crop plots. Increases in growth were irregular, and no significance could be attached to any one treatment.

CINCHONA PHYSIOLOGICAL STUDIES

By Arnaud J. Loustalot, Harold F. Winters, and Norman F. Childers

Growth and composition of cinchona varied under three soil moisture levels.—In March 1946 seedlings of *Cinchona ledgeriana* were transplanted to soil in concrete benches located in three air-conditioned greenhouse chambers, described by Winters et al. (*69, pp. 42–50; 70, pp. 18–20*). The bench in each chamber was divided into three randomized plots separated by a double partition of boards. A uniform mixture of soil was placed in each plot. The wilting point of the soil was 9.5 percent and the field capacity approximately 36 percent. From these data the following treatments were established: (1) Low soil moisture ranging between 9 and 13 percent, (2) medium soil moisture ranging between 18 and 24 percent, and (3) high soil moisture ranging between 30 percent and field capacity.

The temperature in all chambers was maintained at 75° F. during the day and 65° at night. In the previous experiment (*70*) this temperature was found to be the most favorable for growth of *Cinchona ledgeriana*. Humidity was maintained as high as possible by continually spraying the floors with water.

All plots were watered uniformly at regular intervals through March and most of April. On April 25 all plots were watered to field capacity and then allowed to dry gradually until the wilting percentage was approached on June 14. Samples for soil moisture determination were taken at weekly intervals during the drying period and from these data the approximate rate of water loss in each plot was calculated. Since the weights and volume of soil, the wilting

point, and field capacity were the same in each plot it was possible to determine fairly closely the amount of water needed to bring the soil moisture content to the desired levels. Differential soil moisture treatments were begun on June 21.

The experiment was terminated on January 6, 1947, at which time the soil was washed from the roots. Data on height and fresh and dry weights were obtained and the top-root ratio was calculated. The roots and stems were analyzed for quinine and total alkaloids by the method described by Loustalot and Pagán (*37, pp. 153–159; 38, pp. 21–23*). The leaves were analyzed for ash, nitrogen, phosphorus, potassium, calcium, and magnesium.

About 3 months after the treatments were started, small yellow spots, which later became necrotic, appeared systematically between the veins of plants in the high-soil-moisture plots. This disorder, which somewhat resembles magnesium deficiency in other plants (*21 p. 185*), later became more pronounced and occurred on nearly all the plants in the high-soil moisture treatment. Some of the plants lost as much as three-fourths of their foliage. A few of the plants in the medium- and low-soil-moisture plots showed these symptoms but the incidence was less than one-tenth that in the high-soil-moisture plots. This disorder has been observed on young cinchona trees in the station planting at Toro Negro at 3,300 feet elevation.

Seedlings grown at the low-soil-moisture level made less growth as measured by height and fresh and dry weights than seedlings grown under medium- and high-soil-moisture conditions. These differences were significant at the 1-percent level. As might be expected, the percentage of dry matter in the plants grown with low soil moisture was significantly higher than that in plants from the two other treatments. The differences in height and fresh and dry weights between plants grown in medium and high soil moisture were not statistically significant.

Survival was good and fairly uniform in all treatments. The top-root ratios of the plants grown in medium and high soil moisture were not significantly different, though both were significantly greater than the top-root ratio of plants grown under low-soil-moisture conditions.

The roots of plants grown under medium- and high-soil-moisture conditions contained significantly higher total alkaloid and quinine sulfate than the roots of plants grown under low-soil-moisture conditions. There was no statistically significant difference in the total alkaloid content of the stems nor of the quinine sulfate content of the stems and roots of the plants in the three treatments.

The soil-moisture treatments had a marked effect on the mineral composition of the leaves. The percentages of ash, calcium, and magnesium were somewhat higher in the leaves from plants grown under low-soil-moisture conditions than in those from plants grown under medium- and high-soil-moisture conditions. Leaves from plants grown at the high-soil-moisture level contained the lowest percentage of ash, calcium, and magnesium, while leaves of plants in the medium-soil-moisture treatment were intermediate with respect to these constituents. The reverse situation was true, however, with respect to the nitrogen, phosphorus, and potassium content of

the leaves. Leaves from plants grown at the low-soil-moisture level contained significantly the least of these elements. There was no significant difference between the content of these elements in leaves from plants grown in high and medium soil moisture.

CINCHONA INSECT INVESTIGATIONS

By Harold K. Plank and Harold F. Winters

Several species of "stick insects" infested cinchona.—A number of species of insects, mostly Orthoptera, have been noted at various times to feed on the leaves of *Cinchona* spp. and other plants in or near the station nursery at Toro Negro. In some cases damage was insignificant but in others it was sufficient to indicate that the pests could be injurious under conditions favorable for their development.

The insects seen in largest numbers were stick insects, so-called because of the close resemblance of their narrow, nearly cylindrical bodies to small sticks or leafless twigs. Some were of named species, mostly wingless, but others could not be determined beyond the genus.[8] The period of most frequent infestation was from June to December, but no species was ever so abundant that it could not be controlled by hand collection.

Antillophilus brevitarsus Carl fed on the leaves of *Cinchona* and also on the leaves of low, bushy plants, *Pilea* sp., probably *yunquensis* (Urban) Britton and Wilson, that were growing nearby.

Antillophilus restrictus (Redt.), very similar to the preceding species, was found only on *Pilea*.

Aplopus achalus Rehn fed on the leaves of *Cinchona* and of miscellaneous vegetation, including *Pilea*.

Several species of *Dyme* seemed to be the most common on *Cinchona* as well as on other nearby vegetation. Two species were "apparently undescribed." *Dyme haita* (Westw.) was taken only on *Pilea* sp. This form is listed by Wolcott (*71, p. 35*) as occurring in a coffee grove at Lares and on an undetermined shrub at Caguas.

A species of *Lamponius*, "probably *portoricensis* Rehn," appeared to be next in abundance both on *Cinchona* and *Pilea*. Numerous flies of two species were reared from a few specimens that died shortly after collection. One of these species of flies was *Megaselia scalaris* (Loew),[9] which is recorded mostly as a scavenger (*71, p. 346*), and the other represented a "new genus and new species in the tribe Actiini."[10]

Another species of Orthoptera occurring in the Toro Negro nursery was *Microcentrum triangulatum* Brunner.[11] Adults of this dark green katydid were found eating leaves of some *Cinchona* hybrids. Damage was not extensive and control was easily effected by hand col-

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[8] Order Orthoptera, family Phasmatidae. Determined by A. B. Gurney and H. K. Townes, Bureau of Entomology and Plant Quarantine.

[9] Family Phoridae. Determined by C. T. Green, Bureau of Entomology and Plant Quarantine.

[10] Family Larvavoridae. Determined by D. G. Hall, Bureau of Entomology and Plant Quarantine.

[11] Family Tettigoniidae. Determined by H. K. Townes, Bureau of Entomology and Plant Quarantine.

lection. This species has been previously noted as feeding on a number of other plants at many places in Puerto Rico (*71, p. 37*).

Measuring worms, *Microgonia vesulia* (Cram.) var. *olivacea* Warren,[12] were found feeding extensively on the leaves of *Cinchona pubescens* in August. The few larvae encountered were controlled by hand picking. Wolcott records this species on leaves of wild orange and on *Acalypha wilkesiana* (*71, p. 452*).

A few females of the psyllid, *Arytaina* sp., "near *Arytaina cayayensis* Cald.," [13] were found on the under side of the leaves of 3-inch seedlings of *Cinchona ledgeriana* in June. No damage that could be attributed to these insects was observed. Two hymenopterous parasites were reared from the specimens collected, *Discodes* sp.,[14] and *Alloxysta* sp.[15] According to Clausen (*17, p. 271*) the members of the subfamily to which *Alloxysta* belongs are hyperparasites of aphids.

Considerable numbers of the small, flat beetle, *Telephanus pallidus*, Reitt,[16] were found at the same time and in the same habitat as the foregoing. Larvae and pupae of this species were also present. As no injury to the cinchona leaves could be detected, it is probable that both the adults and larvae fed on fungi that were growing on the leaf surface or on the organic matter in the soil, as has been suggested by Wolcott (*71, p. 222*). *Euplectrus platyhypenae* How., a slim black wasp about 1.5 mm. long,[17] emerged in the cage in which the larvae and pupae were being reared.

Numerous shiny black mites about 0.5 mm. in diameter, were seen on the under side of the leaves of 3-foot trees of *Cinchona pubescens* in February. These mites, which had the appearance of small, round beetles, were determined to be possibly a species of *Neoribates* and considered as scavengers.[18] No feeding on the leaves or other parts of the trees could be seen.

Nymphs of a house-infesting cricket caused some damage to 10- to 18-inch potted plants of *Cinchona ledgeriana* in the greenhouse at Mayaguez in November. These nymphs were determined to be *Amphiacusta caraibea* Sauss.[19] The edges of the tender top leaves of a number of plants were eaten and the terminal buds on a few other plants were attacked and killed. After small cardboard rolls having phosphorus paste on the inside were placed near the plants, dead crickets were found on the floor and no more injury occurred.

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[12] Order Lepidoptera, family Geometridae. Determined by Carl Heinrich, Bureau of Entomology and Plant Quarantine.

[13] Order Homoptera, family Psyllidae. Determined by L. M. Russell, Bureau of Entomology and Plant Quarantine.

[14] Family Encyrtidae. Determined by A. B. Gahan, Bureau of Entomology and Plant Quarantine.

[15] Family Cynipidae, subfamily Charipinae. Determined by L. H. Weld, Bureau of Entomology and Plant Quarantine.

[16] Family Cucujidae. Determined by W. S. Fisher, Bureau of Entomology and Plant Quarantine.

[17] Family Eulophidae. Determined by A. B. Gahan, Bureau of Entomology and Plant Quarantine.

[18] Family Galumnidae. Determined by E. W. Baker, Bureau of Entomology and Plant Quarantine.

[19] Family Gryllidae. Determined by A. B. Gurney, Bureau of Entomology and Plant Quarantine.

CINCHONA CHEMISTRY

By Arnaud J. Loustalot, Caleb Pagán Carlo, and Harold F. Winters

Quinine and alkaloid content in different parts of tree not correlated.—An experiment was initiated in June 1946 to study the relationship between size, age, and parts of young cinchona trees and their total alkaloid and quinine content. Sixty 3-year seedlings growing in the cinchona plantation at Toro Negro were measured, numbered, and divided according to size into 12 groups of 5 plants each. Although the trees were grown from open-pollinated seed from the same mother tree, there was considerable variation in size and vigor among those available for the experiment. The 5 largest plants averaged 81 inches in height, while the 5 smallest plants averaged 20 inches.

For the initial sample, one tree taken at random from each group was chosen for analysis and similar samples will be taken at the same season for 4 or 5 successive years. Thus, at each sampling date 12 trees, one from each group, will be dug for analysis.

The trees were divided into the following parts: Roots, lower trunk bark, upper trunk bark, lower trunk wood, upper trunk wood, side branches, and leaves, and analyzed for total alkaloids and quinine sulfate. The data showed that (1) there was no correlation between vigor, as measured by height of tree, with total alkaloid and quinine content; (2) there was no consistent relationship between total alkaloid and quinine content in one part of the tree with that in other parts, although there was some indication of trends which may be more pronounced with more extensive data; (3) total alkaloids were highest in roots and bottom trunk bark. Upper trunk bark, side branches, wood of trunk, and leaves were relatively low in total alkaloid; (4) quinine content of these trees was highest in the bark of the lower trunk and next highest in the roots; (5) the bark of the upper trunk contained much less quinine than that of the lower trunk, and there was no consistent correlation between the two parts; (6) quinine was either entirely lacking or present only in amounts less than 1 percent in the trunk wood and side branches. No quinine was found in the leaves; and (7) there was some indication that when quinine was high in the roots it was also high in the lower trunk bark, although there were some exceptions.

OTHER DRUG CROPS

By Arnaud J. Loustalot and Caleb Pagán

"Fever" plants tested for presence of alkaloids.—Many plants growing in Puerto Rico are used locally for curing fevers. Although there is no clinical or experimental evidence to indicate the efficacy of these so-called medicinal plants it was deemed worth while to examine some of the more common ones for the presence of alkaloids.

Twenty-two different species of plants were collected from various parts of the island. They are listed in table 6. An alcoholic extract and an acidified solution were tested qualitatively for alkaloids with Meyer's, Wagner's, and Dithmar's reagents. The only tissue to give

a strong positive reaction with all three reagents was the bark and root of *Exostema sanctae-luciae* (Kentish) Britten. *Waltheria americana* L. gave a strong test with Wagner's and Dithmar's reagents, but only a weak reaction with Meyer's. Several of the other species gave some indication of the presence of alkaloids but the majority of the plants showed no alkaloid content. Those species that gave positive reactions with the alkaloidal reagents were tested for quinine by the modified thalleoquin reaction (*36; 38, p. 21*) and by the method described by Loustalot and Pagán (*37, pp. 153–159; 38, pp. 21–23*). In every case the results were negative, indicating that the alkaloids present did not contain quinine or quinidine.

An attempt was made to estimate the amount of total alkaloid present by titration (*37, pp. 153–159; 38, p. 23*). In all instances the values obtained were so small that it was evident that only traces of alkaloids are present in some of the species. It is apparent from this preliminary examination that the medicinal properties, if any, of these plants must be due to substances other than alkaloids.

TABLE 6.—*Results of qualitative test for alkaloids in "fever" plants growing in Puerto Rico*

Local common name	Scientific name	Part of the plant tested	Reagents for alkaloids [1]		
			Meyer's	Wagner's	Dithmar's
Guaco	*Mikania cordifolia* (L. f.) Willd.	Whole	—	x	x
"Unknown"	*Exostema sanctae-luciae* (Kentish) (Britten).	Bark and root.	x x x	x x x	x x x
"Unknown"	*Warscewiczia coccinea* (Vahl) Klotzsch.	Bark	—	—	—
Santa Maria	*Eupatorium odoratum* L.	Leaves	—	—	—
Clavellina	*Poinciana pulcherrima* L.	Leaves and stem.	—	x	x
Zarzabacoa	*Zamia diphylla* (L.) Pers.	Whole	—	—	—
Jaboncillo	*Sapindus saponaria* L.	Leaves and stem.	—	—	—
Anamu	*Petiveria alliacea* L.	Whole	—	—	—
Mamey	*Mammea americana* L.	Bark	—	—	—
Habichuela parada	*Macroptilium lathyroides* (L.) Urban.	Whole	x	x x	x x
Mangel	*Rhizophora mangle* L.	Fruit	—	—	—
Yerba amarga	*Parthenium hysterophorus* L.	Whole	—	x	x
Cambustera	*Quamoclit pennata* (Desr.) Voigt.	Whole	—	x	x
Albahaca	*Ocimum basilicum* L.	Whole	—	—	—
Morivivi	*Mimosa pudica* L.	Whole	—	x x	x x
Baobab	*Adansonia digitata* L.	Bark	—	—	—
Uña de gato	*Dozantha unguis-cati* (L.) Rehd.	Whole	—	x x	x x
Ortiga brava	*Urera baccifera* (L.) Guad.	Leaves	—	—	—
San Rafael	*Pectis elongata* H. B. K.	Whole	—	—	—
Viernes Santo	*Phyllanthus niruri* L.	Leaves and stem.	—	—	—
Lengua de vaca	*Pseudelephantopus spicatus* (Juss.) Rohr.	Whole	—	—	—
Basora prieta	*Waltheria americana* L.	Whole	x	x x x	x x x

[1] —=negative reaction.
x=slight positive reaction.
x x=medium positive reaction.
x x x=strong positive reaction.

FOOD-CROP INVESTIGATIONS

VEGETABLE VARIETY TRIALS

By Norman F. Childers, Harold F. Winters, Pedro Seguinot Robles, and Harold K. Plank

Two-year vegetable trials completed at three altitudes.—Reference has been made in previous reports (*10, pp. 31–33; 11, pp. 23–27*)

to a 2-year vegetable trial program conducted at Mayaguez (50 feet elevatiton), Maricao (2,600 feet), and Toro Negro (3,300 feet). The object of this program was to determine the adaptability of several varieties of each of 45 vegetables. All plantings of a given set of vegetables were repeated at 2-month intervals over a 12-month period. About half the vegetables were tested the first year, beginning in January 1945, and the remaining half the following year.

On the basis of the data collected during the past 2 years, the recommended varieties and dates for planting at three locations are summarized in table 7.

Specific results obtained during the 12-month period beginning about July 1946 are given in the following paragraphs.

Results at Mayaguez: The heavy rainfall characteristic of July, August, and September at Mayaguez caused the usual difficulties of greater incidence of disease, excessive soil moisture, washing seed out of the rows, or covering them so deeply that germination was poor. No vegetable tried, other than Slobolt leaf lettuce, was outstanding in performance during this period. Quality and size of the Slobolt bunches were good with no signs of bolting. Other leaf crops were grown with fair success, including mustard, kale, collards, and endive. Alagold pumpkin, seed of which was obtained from L. C. Curtis, Connecticut [Storrs] Agricultural Experiment Station, was resistant to mildew and mosaic. The yellow-flesh fruit, though small, was of excellent quality.

The planting period between August and the middle of October, inclusive, appeared to be one of the poorest seasons of the year for starting vegetables at Mayaguez. The heavy, beating rainfall was again the limiting factor. The only vegetables tried which could be suggested for planting during this period were mustard, turnip, and possibly kohlrabi. Excellent vine growth was obtained with watermelon and the native cantaloup, but yields were very poor. Beet, broccoli, brussels sprouts, carrot, cauliflower, collard, endive, kale, melons, and rutabaga were complete failures mainly because of unfavorable climatic conditions and the damage caused by diseases and insects.

The cool dry days and nights of January to March, inclusive, provided a good growing period for vegetables. Excellent results were obtained with most vegetables, especially beets, carrots, leaf lettuce, Indian cauliflower, chard, collard, and mustard. Incidence of disease was low with the exception of anthracnose which ravaged muskmelon and watermelon. The most persistent insects were aphids and diamondback moth attacking cruciferous crops.

Excellent growth and production were also obtained during the period from April to May, inclusive. Rainfall during this period amounted to only 6.68 inches, while the average monthly temperature was 75.25° F. Incidence of disease was low. Again beets, carrots, leaf lettuce Indian cauliflower, mustard, chard, and collard gave excellent yields. Because of the extended drought, it was occasionally necessary to irrigate.

The extensive use of DDT for control of garden pests greatly favored results obtained during this planting. One pound of DDT in 100 gallons of water resulting from the suspension of 4 pounds of the 25-percent wettable powder in 100 gallons of water was used. Worthy of note was the fact that fortnightly applications of DDT

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TABLE 7.—*Recommended varieties and best seeding months for vegetables at Mayaguez, Maricao, and Toro Negro, P. R.*

Vegetable	For Mayaguez (50 ft. elevation)							For Maricao (2,600 ft.) and Toro Negro (3,300 ft.)						
	Recommended variety	Best months for seeding [1]						Recommended variety	Best months for seeding					
		J-F	M-A	M-J	J-A	S-O	N-D		J-F	M-A	M-J	J-A	S-O	N-D
Asparagus	Mary Washington	x	x	x	0	0	x	Mary Washington	x	x	x	0	0	x
Beans, bush lima	Fordhook 242	x	x	0	0	x	xx	(Very poor results)	0	0	0	0	0	0
Beans, bush snap	Giant Stringless Greenpod	xx	xx	x	0	xx	xx	Bountiful	xx	xx	x	x	xx	xx
	Stringless Refugee	xx	xx	x	0	xx	xx	Logan	xx	xx	x	x	xx	xx
Beans, pole lima	King of the Garden	x	x	0	0	xx	x	Old Florida Pole	x	0	0	0	x	x
Beans, pole snap	Kentucky Wonder, Rust Resistant.	xx	xx	x	x	xx	xx	Kentucky Wonder, Rust Resistant.	x	x	x	0	x	xx
Broccoli	Italian Green Sprouting	xx	x	x	0	x	xx	Italian Green Sprouting	xx	x	x	0	x	xx
Brussels sprouts	Long Island Improved	0	0	0	0	x	x	Long Island Improved	x	x	0	0	x	x
Cabbage, early	Copenhagen Market	xx	x	0	0	x	xx	Copenhagen Market	xx	x	0	x	xx	xx
	Golden Acre	xx	x	0	0	x	xx	Golden Acre	xx	x	0	x	xx	xx
Cabbage, midseason	Wisconsin All Seasons	x	x	x	0	x	x	Wisconsin All Seasons	xx	x	0	x	xx	xx
Canteloup	Smith's Perfect	x	x	0	0	x	x	(Not successful)	0	0	0	0	0	0
	Texas Resistant No. 1	x	x	0	0	x	x							
Carrot	Danvers Half Long	xx	xx	x	x	xx	xx	Danvers Half Long	xx	x	x	0	x	xx
	Improved Red Cored Chantenay	xx	xx	x	x	xx	xx							
Cauliflower	Early Market	xx	xx	x	0	xx	xx	Early Patna	xx	x	0	x	xx	xx
	Early Patna	xx	xx	x	0	xx	xx							
Celery	Utah	x	0	0	0	0	x	(Not successful)	0	0	0	0	0	0
	Golden Self-blanching	x	0	0	0	0	x							
Chard	Lucullus	xx	xx	x	x	xx	xx	Lucullus	xx	xx	x	x	xx	xx
	Fordhook Fancy	xx	xx	x	x	xx	xx	Rhubarb	xx	xx	x	x	xx	xx
Chinese cabbage	Chi Hi Li	xx	x	0	0	x	xx	Chi Hi Li	xx	xx	x	xx	xx	xx
	Wong Bok	x	x	0	0	x	x	Wong Bok	xx	x	x	0	xx	xx
Collard	Louisiana Sweet	xx	xx	xx	x	xx	xx	Georgia	xx	xx	xx	xx	xx	xx
	Georgia	xx	xx	xx	xx	xx	xx							
Corn, sweet	USDA-34	xx	xx	x	0	0	xx	USDA-34	x	x	0	0	x	x
Cucumber	P. R. No. 39	xx	xx	x	0	x	xx	P. R. No. 39*	xx	x	0	0	0	x
Eggplant	Rosita	xx	xx	x	x	xx	xx	Rosita*	xx	xx	x	x	xx	xx
Endive	Broad Leaved Batavian	xx	xx	0	x	xx	xx	Broad Leaved Batavian	x	xx	xx	x	xx	xx
Kale	Bluecurled Scotch	xx	xx	x	x	xx	xx	Dwarf Siberian	xx	xx	xx	xx	xx	xx
Kohlrabi	Early White Vienna	xx	xx	x	x	xx	xx	Short Leaved Early White Vienna	xx	xx	0	x	xx	xx
	Early Purple Vienna	xx	xx	x	x	xx	xx							
Leek	American Flag	x	x	0	0	x	x	American Flag	xx	xx	x	x	x x	xx

Lettuce, head	Great Lakes	0	0	0	0	x	x	(Not successful)	0	0	0	0	0	0
	Imperial 44	0	0	0	0	x	x							
Lettuce, leaf	Slobolt	xx	xx	xx	x	xx	xx	(Not successful)	0	0	0	0	0	0
	Black Seeded Simpson	xx	xx	x	0	xx	xx							
Mustard	Southern Giant Curled	xx	xx	x	0	xx	xx	Florida Broad Leaf	xx	xx	xx	xx	xx	xx
	Fordhook Fancy	xx	xx	x	0	xx	xx							
Okra	White Velvet	xx	xx	xx	x	xx	xx	White Velvet*	x	x	x	0	0	0
	Perkins Long Green	xx	xx	xx	x	xx	xx							
Onions, green	New Long White Bunching	xx	xx	x	0	xx	xx	New Long White Bunching	xx	xx	xx	xx	xx	xx
	Louisiana Red Creole	xx	x	x	0	xx	xx	Yellow Bermuda	x	x	0	0	xx	xx
Parsley	Extra Triple Curled	xx	xx	xx	x	xx	xx	Extra Triple Curled	xx	xx	xx	x	xx	xx
	Plain	xx	xx	xx	x	xx	xx	Plain	xx	xx	xx	x	xx	xx
Parsnip	Hollow Crown	0	0	0	0	x	0	Hollow Crown	x	xx	0	0	x	x
Pea	Melting Sugar	x	0	0	0	x	x	Melting Sugar**	x	x	0	x	x	x
Pepper	California Wonder	xx	xx	x	0	xx	xx	Isabela Selection 21	xx	xx	x	0	xx	xx
	Ruby King	xx	xx	x	0	xx	xx	Blanco del Pais	xx	xx	x	0	xx	xx
Potato	Red Bliss Triumph	0	0	0	0	x	x	(Not planted)	0	0	0	0	0	0
Pumpkin	Alagold	xx	xx	x	0	xx	xx	Small Sugar*	xx	xx	x	0	xx	xx
	Kentucky Field	xx	xx	x	0	xx	xx							
Radish	Earliest Scarlet Button	xx	xx	x	x	xx	xx	Earliest Scarlet Button	xx	xx	xx	x	xx	xx
	Early Scarlet Globe	xx	xx	x	x	xx	xx							
Rhubarb	Victoria	0	0	0	0	x	0	Victoria	xx	x	0	0	x	x
Rutabaga	American Improved	x	x	0	0	x	x	American Improved	xx	x	0	0	x	x
Spinach	New Zealand	xx	xx	xx	x	x	xx	New Zealand	xx	xx	xx	x	x	xx
Squash	Black Zucchini	xx	x	x	0	xx	xx	Cocozelle*	xx	xx	x	0	x	xx
	Golden Yellow Straight Neck	xx	xx	x	0	xx	xx							
Tomato	Rutgers	xx	x	0	x	xx	xx	Marglobe*	xx	xx	x	0	x	xx
	Michigan State Forcing	xx	x	0	xx	xx	xx	Pritchard*	xx	xx	x	0	x	xx
Turnip	Purple Top White Globe	xx	xx	x	0	xx	xx	Purple Top White Globe	xx	x	x	0	x	xx
	Early White Milan	xx	xx	x	0	xx	xx							
Watermelon	Improved Tom Watson	x	x	0	0	x	x	(Not successful)	0	0	0	0	0	0

[1] Legend:
xx—indicates planting month for best results.
x—indicates planting month when crop may be grown with moderate success.
0—indicates month least desirable for planting.
*—successfully grown at Maricao only.
**—successfully grown at Toro Negro only.

kept the cruciferous crops free of the diamondback moth (*Plutella maculipennis* Curt.), the worst pest of cabbage in Puerto Rico. Previous to this time arsenate of lead and rotenone had been the insecticides most used, but weekly applications did not effectively control this pest.

Results in Maricao (2,600 feet): A good garden was maintained at Maricao during the summer months of July, August, and September. Peppers and eggplant performed exceptionally well. Chinese cabbage produced small but good quality heads. Sweet corn (USDA–34) grew well with but little disease and matured medium-size ears of good quality; good yields were obtained only after liberal fertilization with a complete 6–9–10 fertilizer. Okra grew and produced only during the warm summer months and failed repeatedly during other seasons. A dry period during June and July caused some difficulty in the germination and early growth of seeds planted in June. Leafhoppers were particularly damaging to bush beans during the summer months. The best yield of cucumbers was obtained from this planting. All the cucurbits showed mildew damage, but in spite of this disease the Cocozelle squash produced a fair crop before the vines were killed; cantaloup, watermelon, and pumpkin were killed before fruiting.

Vegetables that matured and performed satisfactorily at Maricao during the months of October to December, inclusive, were as follows: Chinese cabbage, snap bean, sweet corn, eggplant, okra, mustard, bunching onion, leek, and pepper. Most of these crops were from summer plantings. Although most of the Chinese cabbage headed during this period, the heads were not so large as those produced earlier in the year during the cooler months of February to June, inclusive. Eggplant performed well, showing good adaptation to the Nipe clay soil and location. It was necessary to replant onions and leeks because of beating rains shortly after germination. The snap bean produced rather heavily for a short time but was short-lived because of wet weather. Plants which performed poorly at Maricao during this period were: Beet, Kentucky Wonder pole bean, a local unknown variety of cantaloup, Swiss chard, Puerto Rico No. 39 cucumber, Small Sugar pumpkin, Victoria rhubarb, Cocozelle squash, and Tom Watson watermelon.

Vegetables maturing from January to April, inclusive, at Maricao which performed satisfactorily were: Chinese cabbage, mustard, snap bean, cucumber, pumpkin, and sweet corn. A distinct seasonal effect was noticed in certain crops. Eggplant stopped growth and setting fruit during the cool dry months. Okra produced practically nothing from an August planting, and a November planting did not make sufficient growth to support fruiting. However, an okra planting made in June grew vigorously and continued fruiting until mid-December. Yellow Bermuda onion plants failed to produce bulbs during this season. Plants which performed poorly during this period were: Okra, pole bean, pepper, eggplant, leek, garlic, onion, lima bean, cantaloup, rhubarb, beet, chard, watermelon, and squash.

A planting of asparagus seedlings made in June 1946 made particularly good growth during the summer and fall months. After the May rains of the following year the plants resumed growth and produced a fair crop of usable spears. This vegetable would seem to

have a place in the home garden in Puerto Rico at elevations from 1,500 to 2,600 feet.

Results at Toro Negro (3,300 feet): A good vegetable garden was maintained during the summer months of July, August, and September at Toro Negro. This was probably due to less than usual rainfall during June, July, and August. An excellent crop of peppers was matured in August and September. Beans and Swiss chard produced well. Chinese cabbage made fair growth and headed during the summer months, although the heads were somewhat smaller than those produced during the spring period. Chinese cabbage appeared to be fairly resistant to cabbage rot, but this disease was so severe during the rainy months that it was almost impossible to grow most cabbage varieties. Leek grew well from seed at this elevation and showed evidence that it can be left in the ground over a long period, or until needed for table use. Beet produced well only when fertilized with sodium chloride (table salt); 500 pounds per acre more than doubled the yield. These results were duplicated at Mayaguez. The bunching-type onion and Yellow Bermuda also did well, but were more subject to attack by thrips than the leek. Cucurbits performed poorly and most of the plants were defoliated and killed by mildew before fruiting began.

Crops that performed best during the months of October to December, inclusive, were rhubarb, bunching onion, leek, beet, bean, mustard, Swiss chard, pepper, and Chinese cabbage. Pepper showed good growth and production but there was some fruit rot due to heavy rains at maturity. The beets were irregular in maturing and the bean plants were short-lived as a result of an attack by mildew. Vegetables which performed poorly or were complete failures were: Okra, Small Sugar pumpkin, Tom Watson watermelon, a local unknown variety of cantaloup, and Cocozelle squash.

Vegetables harvested at Toro Negro from January to March, inclusive, which performed satisfactorily were—Ceylon yam, snap bean, chard, beet, Chinese cabbage, leek, bunching onion, mustard, and Puerto Rico pepper selection No. 21. Vegetables which performed poorly during this period were eggplant, butter bean, lima bean, okra, sweet corn, cantaloup, cucumber, pumpkin, squash, and watermelon. An effect of the cool season and short days was quite evident. Eggplant and pepper made poorer growth at this time than during the summer. Yellow Bermuda onion failed to form bulbs. More flowering was noticed in Chinese cabbage than during other seasons, amounting to approximately 25 percent.

Vegetables maturing from April to June, inclusive, which gave the best results were onion, cabbage, turnip, mustard, radish, carrot, and Chinese cabbage. Those that performed poorly were pumpkin, pepper, butter bean, lima bean, sweet corn, eggplant, leek, and garlic. Asparagus seedlings planted in June 1946 made fair growth, but did not compare with those at Maricao. The plants failed to produce spears of edible size during the current season.

VEGETABLE INVESTIGATIONS

By Norman F. Childers and Pedro Seguinot Robles

Ridges and staking tomatoes resulted in higher yields during summer.—Tomato cultivation near Mayaguez during the summer

rainy season is usually a failure. Diseases, insects, and the poor setting of fruit result in such low yields that even the high price of tomatoes during this period does not offset the cost of production. In order to find a practical method of handling tomatoes during this period, an experiment was undertaken in which the variety Michigan State Forcing was grown under the following treatments: (1) Ten-inch ridges with a heavy roofing paper as mulch, (2) 10-inch ridges with plants trained to one stem on bamboo stakes, (3) grown under Celloglass roofing with plants trained to strings, and (4) level beds 12 inches high with plants trained to bamboo stakes. Each treatment consisted of two replicates of 32 plants each. One replicate was treated with D–D soil fumigant previous to planting and the other was untreated.

The field planting was made on September 16–19, 1946. Where level planting was used the spacing was 24×18 inches. In the ridged plots the spacing was 36×18 inches.

Data obtained indicated that ridging and training result in higher yields of fruit during the high rainfall season. Although the yields of all plots were small, the fumigated plots yielded almost twice as much as the untreated plots. The data are given in table 8.

The following observations were made: (1) A 24″×18″ spacing under Celloglass covering was too restricted for good production; (2) a surface cover of dried grass on the green-colored mulch paper was necessary to protect the roots and tops of the tomatoes from excessive heat; (3) soil fumigation resulted in an earlier blooming and ripening of approximately 3 days; and (4) the only satisfactory yield obtained during the rainy season was by fumigating with D–D plus ridging and staking.

TABLE 8.—*Effect of ridging, staking, soil fumigation, and Celloglass covering on yield of tomato during the rainy season in Puerto Rico*

Treatment	Yield per plant	Treatment	Yield per plant
	Pounds		*Pounds*
Ridges, training, D–D	4.7	Ridges, mulch, D–D	1.5
Ridges, training	2.6	Ridges, mulch	.6
Beds, training, D–D	2.2	Celloglass, D–D	.4
Beds, training	1.9	Celloglass	.3

GRAVEL CULTURE

By NORMAN F. CHILDERS and HECTOR R. CÍBES

Tomatoes and lettuce grown successfully by gravel culture.—Excess soil moisture due to heavy rainfall in summer is the chief limiting factor in vegetable growing at Mayaguez. Several methods have been tested in the field for growing tomatoes in summer, but none of them have been entirely satisfactory when rainfall is particularly heavy.

The gravel culture system of growing tomatoes which proved successful throughout the Tropics in military camps of World War II has been tested under greenhouse conditions during the past year.

Two raised concrete beds were constructed in a greenhouse on the station grounds in accordance with recommendations of Laurie and

Kiplinger (*34, p. 61*). An adjacent concrete bed, used as a soil check, was also constructed with a porous bottom for drainage. The beds are 4 feet wide by 45 feet long. Solution tanks accommodating 40 percent by volume of the bed areas are located beneath the center bed. The gravel culture beds are filled with creek gravel, screened to pebbles of ¼- to ½-inch size.

The WP Ohio solution is employed (*34, pp. 62–63*). The Spurway method (*57*) of periodic testing the nutrient solutions for proper chemical levels is used; the necessary chemicals added to the solution tanks according to need. The water level in the tanks is kept at a fairly constant level by adding tap water every day or two; the solution is not renewed during the entire crop.

The nutrient solution is distributed to the beds by sump pumps operating three times daily at 7:30 a. m., 12:00 noon, and 3:00 p. m. The pumps are actuated by an electric time clock and operate for 15 to 20 minutes, after which the solution drains back into the tanks by automatic syphon.

One full crop of tomatoes was completed during the winter season of 1946–47. Seed of the Michigan State Forcing variety was planted on October 18, 1946, in pockets of sandy loam soil at the respective planting locations in the gravel and soil benches. Two rows of tomatoes were set in each bed at a distance of 22 inches in rows 24 inches apart.

The soil bed was watered daily throughout the trial. One-half strength WP nutrient solution was pumped to seedlings in gravel beds during the first 6 weeks, but due to the abundance of sunshine in Mayaguez during winter, these plants grew spindly. The solutions were made up to full strength and immediately the plants showed stimulation, doubling their girth within 2 weeks. The tomatoes were trained upright to a single stem with heavy strings suspended from upper cross wires. Commercial bordeaux mixture was applied at 3- to 4-week intervals but because the soil and gravel were not initially sterilized, leafmold caused injury to the lower leaves by the end of the experiment.

No manure or organic matter was added to the soil used in the check bed but a complete fertilizer of the formula 10-10-5 was applied at the rate of 1,000 pounds per acre at planting and 6 weeks later.

While vegetative growth was as good or better in the soil bench than is usually attained in the field at Mayaguez, it was obviously not as good as that obtained in gravel culture. Average height of the plants grown in soil was 9.8 feet and for plants grown in gravel culture, 14.9 feet. The difference of 5.1 feet was highly significant. Girth of tomatoes grown in gravel culture was between ½ and ¾ inch, whereas that for plants grown in soil was, in general, less than ½ inch. Growth of the plants in soil was fairly good for the first few weeks but toward the end of the experiment growth was thin and slow; foliage color was an abnormally dark bluish green. Foliage of plants in gravel culture was a normal green.

Plants in soil and gravel beds were statistically analyzed when the crop was completed on February 6, 1947. Yields for plants in gravel were more than twice as great as those in soil with the exception of one cut of 44 pairs. Average yield per plant in gravel was 6 2 pounds and for soil, 2.7 pounds, a highly significant difference at the 1-percent level. The quality of the tomatoes in both treatments was ex-

cellent and superior to that of average tomatoes harvested in the field in either summer or winter at Mayaguez.

A second crop of tomatoes was grown during the summer of 1947. Before the crop was planted, manure at the rate of 10 tons per acre was added to the soil bench and thoroughly mixed. The soil and gravel were thoroughly disinfected with 40 percent formalin, 1 part to 50. The floors, solution tanks, and entire lower section of the greenhouse were sprayed with formalin to reduce the sources of disease. This practice was worth while since little or no leafmold appeared during the first 10 weeks.

Two varieties of tomatoes were grown. Half of each bench, one soil bench and two gravel culture benches, was devoted to the Michigan State Forcing variety and the other half to Firesteel. Firesteel is recommended for its ability to set fruit well during hot weather. Firesteel being a determinate low-growing variety was planted in the south half of the benches to afford maximum sunlight to both varieties throughout the day. Seed were planted on June 6, 1947, in a flat of sand supplied with a full nutrient solution, using the slop-culture system. The seedlings were transplanted to the benches on July 10 when 4 to 6 inches high. Growth in all beds was excellent and about equal as of September 5, 1947, when the Michigan State Forcing variety was 5 to 6 feet high and the Firesteel, 3 to 4 feet. Firesteel began to set fruit 3 weeks ahead of the Michigan State Forcing; set was exceptionally heavy at first, with 7 to 10 fruits per cluster. Some fruits reached a diameter of 3 to 4 inches. Michigan State Forcing set lightly at first, but moderately heavy later.

Blossom-end rot was prevalent on the first clusters of some Firesteel plants, but other plants of this variety showed none. This variety did not appear to be entirely homozygous as indicated by large differences in over-all vigor and blossom-end rot. Michigan State Forcing was uniform in growth and showed no blossom-end rot, summer or winter. The disease was more prevalent in the soil bench than in gravel culture.

In connection with this experiment good crops of Slobolt leaf lettuce were grown between the tomato plants in late winter and summer. Lettuce seedlings were transplanted to the gravel and soil beds with the tomatoes. Other short-season crops such as radishes and bunching onions likewise could be interplanted with tomatoes inasmuch as there is little or not competition between the crops for moisture and nutrients; also, these crops are harvested before shading from the tomatoes becomes a limiting factor.

On the basis of these results, it is apparent that excellent growth can be obtained in gravel culture under glass in Puerto Rico. Although a complete record is not available for summer, it is evident from the winter crop that a higher yield of quality tomatoes can be obtained by this method than from fertilized river-bottom soil. Results to date for summer appear encouraging. There seems to be a definite place in Puerto Rico for a limited acreage of high quality vegetables grown by gravel culture, particularly during summer when the market supply and quality are low.

For use under commercial conditions in Puerto Rico the plant beds can be sunk on level ground and provided with a slight tilt for proper pumping and drainage (*2*). One solution tank can supply 20 or

more beds, each bed 3 to 6 feet wide and 100 or more feet long. Where no over-all roof is provided, a bypass can be used near the covered concrete solution tank to divert the rainwater and keep it from falling into the beds and from diluting the nutrient solution.

At the prevailing high prices in 1947 in Puerto Rico a concrete bed 6 feet wide and 100 feet long with 2- to 2½-inch walls can be constructed for about $200. Asphalt (1 part asphalt to 9 parts dry river sand) is considered a satisfactory substitute for concrete; a similar bed of this material can be constructed for about $100. The initial cost in laying out a gravel culture system is the main expense involved. Labor for plowing, disking, weeding, irrigation, disease and insect control, changing the soil, adding manure, and similar items is either eliminated or considerably reduced for the gravel culture system as compared with field crop management. Supervision and help, however, must be of high quality and specially trained.

Cost of production of some crops by gravel culture is less than by soil (*33, p. 46*). Army costs in Japan for the production of tomatoes, radishes, peppers, and lettuce were higher than under field management with soil; on the other hand, cost of producing cucumbers was less than one-half by gravel culture (*3, p. 8*). If the overhead costs were spread over a period of years, however, it is probable that the gravel culture system would be the cheaper, as suggested by Kiplinger and Laurie (*33, p. 46*). Also, under Puerto Rican conditions where outdoor beds can be used for growing three or more crops a year, depending upon the vegetable, the overhead costs should be further reduced as compared with areas such as Florida (*40, pp. 64–67*) and Japan, where outdoor beds may lie idle for a few months in winter.

PLANT INTRODUCTION AND PROPAGATION

INTRODUCTION AND DISTRIBUTION

By Edward P. Hume and Rubén H. Freyre

Plants and seed received from 17 countries and 6 States and Territories.—During the year the station received 110 accessions of seeds and plants for testing from: Canal Zone 1, Ceylon 6, Chile 9, Colombia 5, Costa Rica 27, Cuba 75, El Salvador 8, Ecuador 1, Guatemala 14, Honduras 28, India 1, Jamaica 3, Liberia 1, Mexico 4, Panama 9, South Africa 5, and Trinidad 17.

Shipments of plants made to 49 countries.—Plants distributed during the year totaled 27,939. Seed distributions included 136 pounds of seeds of ornamentals, 186 pounds USDA–34 sweet corn, 120 pounds tropical kudzu, and 73 pounds soybeans. Other distributions included propagating material amounting to 1,445 pounds of essential oil plants, 2,050 pounds of ginger rhizomes, and 206 square feet of sod of Manila grass (*Zoysia matrella* (L.) Merr.). These totals include seeds and plants shipped to Algeria, Antigua, B. W. I., Argentine, Australia, Bahamas, B. W. I., Barbados, B. W. I., Belgian Congo, Brazil, British Guiana, Canary Islands, Canal Zone, Chile, Colombia, Costa Rica, Cuba, Dominica, B. W. I., Dominican Republic, East Africa, Ecuador, El Salvador, France, French Guiana, Grenada, B. W. I., Guatemala, Haiti, Hawaii, Honduras, India, Jamaica, B. W. I., Java, N. E. I., Kenya (Africa), Liberia, Malaya, Mexico, Nicaragua, Palestine, Pan-

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ama, Paraguay, Peru, Philippine Islands, Portugal, Portuguese East Africa, Sierra Leone Protectorate, St. Kitts, B. W. I., Tanganyika Territory, Trinidad, B. W. I., Union of South Africa, Venezuela, and the United States Virgin Islands.

Considerable interest in Manila grass was aroused as the result of the publications by Childers (*9*) and Childers and White (*12*) on this new grass for Puerto Rico and the Tropics. Demands were so heavy as to necessitate the limiting of distribution of 2 square feet of sod per person. In addition, numerous requests for seed and planting material of this grass were received from interested parties in the continental United States.

Tropical kudzu (*Pueraria phaseoloides*) has proved to be an outstanding legume for pasture and cover crop use. The widespread interest in this crop can be ascertained from the distribution of nearly 120 pounds of seed during the year, aside from considerable amounts sold by local farmers collecting seed from their own plantings. Demands were so heavy that distribution per person had to be limited from a few ounces to 2 pounds, depending on the request.

Yam beans gave low yields with poor table quality.—An experiment designed to determine the yield, moisture content, and palatability of 10 strains of yam beans, *Pachyrhizus* spp., was started on June 11, 1946. A comparison between staking vs. no-staking and time of harvest for each strain also was studied. Nine strains were obtained from plants grown at the station from seeds supplied by Robert T. Clausen, Cornell University. The other strain came from the Compañia Exportadora e Importadora de Mexico, Sociedad Anonima.

Both plots consisted of one row of each strain plus a guard row at each end. The rows were 4 feet apart on the contour with 15 plants set 2 feet apart in each row.

The seed were sown June 11 and transplanted to the field a month later. The roots were harvested at 5 and 6 months after transplanting to the field. The yields were generally low as compared to other root crops commonly grown in Puerto Rico. The best yield was obtained from the Guatemalan strain 44–24 totaling 1,763 pounds per acre. The next best was a Mexican strain from the vicinity of Tampico which yielded 1,258 pounds per acre.

The staked plots yielded only an equivalent of 48 pounds per acre more than the nonstaked. The crop required dusting to control the leaf beetle, *Cerotoma ruficornis*. Yam beans are also susceptible to mole crickets and root weevils. Palatability trials of boiled roots disclosed none particularly appetizing. On the basis of these results investigations on *Pachyrhizus* as a food crop have been discontinued.

Sorghum varieties varied widely in test plots.—The sorghums constitute an important grain crop in many tropical countries. The station introduced for trial the species *Sorghum halepense* (L.) Pers. and eight varieties of *S. vulgare* Pers., including four Kavirondo varieties, the white, red, black, and Mtama, from Kenya, East Africa, where they are considered perennials.

One ounce of seed of each variety was broadcast early in August 1945 in a 6×8 foot test plot. There was considerable variation in seed germination; in some cases only one or two clumps developed. There was a wide range in height and stem diameter of culms within plots as well as between varieties.

The Mtama strain of the Kavirondo group showed the greatest tendency to lodge. Hegari was the first to set seed. Attacks by birds necessitated bagging of all seed heads of this variety, as well as the Early Guinea Corn, a late-maturing, but higher-yielding strain.

The seed yields were generally low but cannot be considered of maximum production because of nonuniform stands. Both Early Guinea Corn and the Sudan grass seed were collected before full maturity in order to make comparative palatability trials while all the types were still succulent. The highest forage producers were Red and White Kavirondo, Early Guinea Corn, and *Sorghum halepense*. Percentage forage consumed by Guernsey cattle was about the same for all sorghums. *S. halepense* and Sweet Sudan grass were the highest, with 84 percent, and hegari (55 percent) and Mtama Kavirondo (60 percent) were the lowest.

While these trials were limited, it appeared that the Early Guinea Corn was the best suited for Puerto Rican conditions, yielding almost twice as much grain as the next highest. It is resistant to disease and has strong upright growth with little tendency to lodge. The stems are large and succulent and the leaves wide, producing moderate roughage which is fairly well consumed. The Kavirondo sorghums, particularly the White strain, should be considered for dry sections of the island since they are reported to be highly drought-resistant.

Manila grass plugs thrived only when established grasses were weak.—In August 1945 a propagation experiment with four lawn grasses was undertaken with the following objectives: (1) To compare the ability of each of four grasses to invade from plugs and take over established lawns of each of the other three species; (2) to determine the relative ability of Manila grass (*Zoysia matrella*) to take over established lawns under full sun and partially shaded conditions from plugs and from sprigs; and (3) to determine the time required to establish a Manila grass lawn from plugs at two spacings, with and without fertilizer in established lawns of three other grasses. The other three grasses included were carpet grass (*Axonopus compressus* (Sw.) Beauv.), Java grass (*Polytrias praemorsa* (Nees) Hack.), and centipede grass (*Eremochloa ophiuroides* (Munro) Hack.). Plugs approximately 1½ inches square were cut from lawns and planted in established lawns of the other species at 12-inch spacings unless otherwise noted. Except for watering at the time of planting and unless otherwise noted these lawns received standard lawn care, fairly regular mowing, and yearly fertilization.

Java grass lawns retarded or eventually eliminated plugs of Manila and centipede grasses except for weak or dead spots where the plugged grasses increased in size up to 10 inches. Carpet grass plugs, on the other hand, increased slowly in size even in vigorous portions of the Java grass lawns. The vigorous growth of carpet grass practically eliminated plugs of the other species planted in it.

The rate of growth of the established centipede lawn was insufficient to prevent increases from Java grass plugs which covered about one-sixth of the centipede plot. Carpet grass plugs also increased in size but somewhat more slowly. Manila grass plugs increased in size only in weak spots of the centipede lawn.

Stolons from grass plugs of other species which were set in Manila grass lawns had difficulty in rooting through the Manila grass because

of the dense turf. The Java grass plugs increased in size to several times the original, but growth of the carpet and centipede plugs was slow and variable.

In weak areas of a centipede lawn, Manila grass plugs grew well. A comparison of spriging versus plugging indicated slightly better growth from plugs and both grew better in partial shade than in full sunlight. A greater increase in size was noted where fertilizer was applied.

TROPICAL FRUITS

By Edward P. Hume and Rubén H. Freyre

Lanolin favored early growth of mango scions.—Lanolin alone and 2 percent naphthaleneacetamide in lanolin were each applied to the tips of 20 scions of mangos (*Mangifera indica* L.) cut just below the terminal bud. In other treatments these two substances were also applied to the mango stocks where they had been cut 6 inches above the point of union. Scions of the variety Bombay Yellow grafted onto seedlings of Itamaraca about 18 months old were treated after grafting.

The application of 2 percent alpha naphthaleneacetamide in lanolin caused a reduction in percentage "take," and when applied to the scions reduced the amount of new growth. The concentration of the hormone may have been too high for best results. The 2-percent concentration was chosen because the application was made some distance from the union. Considerable proliferation of stock tissue at the sides of the graft was noted in three or four cases where stocks had been treated with the hormone. Lanolin treatments increased the development of new scion growth. Both scion treatments resulted in a lower percentage take than either of the respective stock treatments or the check. This was particularly true where the hormone was applied to the scion and all of the hormone had to pass through the grafted surface to move out of the scion. The additional cut surface also increased exposure to disease organisms.

The results of this trial indicate a possible benefit from the use of lanolin in the wound dressing when applied to the cut surface of the stock.

Bark-grafted mango varieties vary in "take."—In a stock-scion compatability study 15 superior mango scion varieties were grafted onto each of 15 lines of seedling stocks. The scion varieties consisted of Mulgoba, Alphonse, Bombay Green, Bombay Yellow, Amini, Bulbulchasm, Paheri, Maller, Fajri Long, Martinique, Haden, Pico, Sufaida, Cambodiana, and Concord; the seedling stocks were grown from seed of the following varieties: Paheri, Amini, Sunahra, Mulgoba, Kachmahua, Fajri Long, Divine, Bulbulchasm, Cambodiana, Totafari, Itamaraca, Alphonse, Haden, Sandersha, and Del Pais. Standard technique for mango grafting was followed. The averages for percentage take were calculated on the basis of 235 to 361 grafts.

The percentage take of Paheri seedlings was best (37.2) with Amini second (32.0). The grafts from seedlings of Del Pais, a native seedling resembling "Mango Blanco", were the poorest (14.3 take).

The average percentage take of the better scion varieties when grafted on all seedling stock lines were: Mulgoba, 44.6; Alphonse, 40.6; Bombay Green, 39.7; Bombay Yellow, 38.9; and Amini, 37.0

percent. The take of several good quality varieties such as Martinique, Haden, and Cambodiana were so poor that their propagation by bark grafting appeared questionable.

Tongue grafting of mangoes gave superior results.—An experiment was designed to compare the effectiveness of four types of vegetative propagation for mangos. Seedlings of the Amini variety were used as stock, and all treatments, shown in table 9, included 25 Alphonse and 25 Mulgoba scions. The stock plants were forced into vigorous growth by the application of fertilizer 2 weeks prior to grafting. The stock tops were cut back about 1 foot at the time of grafting. New shoots and basal sprouts were removed at frequent intervals. None of the stocks were completely cut back until the new scion growth reached at least 1 foot. The data obtained after the first and third months are listed in table 9.

The whip graft treatment, where scions were grafted to pieces of root and placed in a propagating bench, was a complete failure. Shield budding in general was unsatisfactory because the stocks were nearly 2 years old and the shields had to be cut extra thick in order to be pushed under the tough bark without bending or breaking. As a result, the cut surface on the shield was not sufficiently flat to make a good union with the stock cambium. The side bark graft or scion bud method gave fair results. This type of graft has occasionally failed after the scion has made considerable growth. The development of new tissue between the cambium lines across the top of the graft is slow and water may enter after the grafting wax disintegrates.

TABLE 9.—*The percent "take" and extent of new growth with various methods of mango grafting*

Grafting method	Grafting "take" [1]				Average both varieties		Average new growth	
	Mulgoba		Alphonse					
	1 month	3 months	1 month	3 months	1 month	3 months	1 month	3 months
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Inches*	*Inches*
Shield bud	20	20	16	18	18	18	0.14	9.0
Side bark graft (or scion bud)	80	64	64	52	72	58	2.36	13.0
Side tongue	60	[2] 40	88	76	74	58	5.59	14.5
Veneer graft	84	48	96	64	90	56	.07	2.6

[1] Includes dormant grafts apparently healthy.
[2] A sewerage ditch dug nearby may have destroyed or damaged some of these.

The tongue graft is more difficult to perform but it has a better chance for success since the scion is tightly held in place and the area of cambium contact is increased. The data show a rapid new scion growth with this treatment, an important factor in the rate of knitting. This method appears most favorable for general mango grafting, but has not been tried for a sufficiently long period to be recommended as a general practice.

The veneer or cinchona veneer graft, as this variation is sometimes called, requires strict control of the depth of stock cut in order to expose the same distance between cambium lines as those of the cut surface of the scion. Many of the scions of this treatment remained dormant while several flushes developed in other treatments. After 3 months more than half of the veneer grafts were still dormant.

Avocado buds from central zone of the bud sticks equally satisfactory for propagation.—Bud sticks collected from mature trees of Guatemalan and hybrid varieties of avocados (*Persea americana* Mill.) during August and September were grafted onto 1-year-old West Indian seedlings grown in gallon cans. In each case the buds were removed in numerical order from tip to base of bud sticks. The first or topmost bud taken was the one below the terminal cluster having enough surrounding bark to make a satisfactory shield, usually about 1 inch from the tip. The lowest bud was usually at the base of the last flush, occasionally in the upper section of the previous flush. The percentage success after 4 months from the second through the eighth bud was about the same, 42 to 54 percent. Above and below this zone the results were unsatisfactory. Propagation on older stocks was less successful because many buds fell from the shield or were covered by callus before they started growth, indicating the desirability of budding on young stocks.

The percentage success of scion grafting with respect to various varieties on West Indian stock was as follows: Itzamna 94, Kanan 61, Winslowson 57, Collinson 50, Panchoy 39, and Puebla 14.

Several treatments not effective in improving growth of mangosteen seedlings.—Chlorotic mangosteen (*Garcinia mangostana* L.) seedlings growing in gallon cans of peat were given various treatments in an effort to alleviate the chlorosis and improve the vigor. The peat in all cases was removed from the roots and 10 plants of each group were treated before replanting. In some cases, additional treatments were applied to the surface during the year's duration of the experiment. Neither ferric sulfate, lime, or brewer's yeast nor the mixing of manure, charcoal, or soil containing roots of old mangosteen trees with the peat resulted in better growth or less chlorosis of the seedlings than in the check plots.

FORAGE CROPS

By Edward P. Hume and Rubén H. Freyre

Leguminous cover crops show wide variations in growth.—The desirability of securing cover crops adapted to Puerto Rican conditions is extremely important for soil improvement and soil conservation. During the past 2 years the station has introduced a total of 21 species of legumes, of which all but 3 were secured from foreign countries. Observational plots 4 by 7 feet were used. Seed mixed with sand for more uniform distribution were sown or broadcast; in the case of large plants, were planted on 1½-foot centers. The percentage germination was extremely variable, ranging from practically zero to almost perfect. Most species were sown either in August or November 1946. Those planted in November required several irrigations to establish the plants during the dry weather. One or two weedings were required during the first month.

Among the 10 vine types of cover crops tried, *Canavalia maritima* (Aubl.) Thouars, *Indigofera endecaphylla* Jacq., and *Stizolobium deeringianum* Bort. showed most promise and invaded established cover crops in adjacent plots. The last named is particularly relished by domestic animals. Regular replantings are necessary because it dies after seeding, unless a volunteer crop is produced. The two

species of *Centrosema* and the *Stizolobium aterrimum* Piper and Tracy suffered during dry periods showing partial defoliation, with resultant competing weed growth. *S. aterrimum* became vegetative after flowering, indicating a perennial character. *Calopogonium mucunoides* Desv. and an undetermined species of *Canavalia* died out after flowering. The latter is vigorous, developing woody stems and covering large areas. The *Calopogonium* showed little vigor. The remaining species did not grow satisfactorily under these trials as complete cover was not established within 6 months. The *Dolichos hosei* Craib has thrived well under more shaded conditions. *Phaseolus calcaratus* Roxb. produced a fairly heavy cover but was severely attacked by the beetle *Cerotoma ruficornis* Oliv. The *Vigna* sp. was similarly attacked and did not produce as heavy a cover.

The shrub-type cover crops were generally less satisfactory for rapid cover and most of these did not produce much organic matter. The best shrub-type cover crops were the species of *Tephrosia* which continued growth even during long dry periods. The woody stems decomposed slowly, especially those of *T. candida* (Roxb.) DC. The Totiempo, a perennial variety of pigeonpea (*Cajanus cajan* (L.) Millsp.) grew well, supplying a cash crop over a long period and forage for stock feed, but the total amount of organic matter produced was not large. This variety appeared to be less susceptible to "Rizado," a serious disease of pigeonpeas. The *Crotalaria usaramoensis* Baker f. was the most satisfactory of the three crotalarias tested, making a complete cover, vigorous growth, and producing seed over a long period. *Desmodium nicaraguenses* Oerst., previously planted in another plot, made practically no growth during the first winter but later grew rapidly, reaching a height of 15 feet. The extremely short life cycle of the *Sesbania* sp. precludes its use for anything but a short catch crop. The small benefit derived makes its use questionable. *Lespedeza cuneata* (Dumont) G. Don and the lupine, *Lupinus angustifolius* L., the two other cover crops tested, germinated very poorly and did not last more than a few weeks in the field.

The best cover crops grown in these trials include the velvetbean, (*Stizolobium deeringianum*) and *Canavalia maritima* among the vine types, and *Tephrosia* spp. and *Crotalaria usaramoensis* among the shrub types, while the pigeonpea (*Cajanus cajan*) Totiempo served a dual purpose. No direct comparisons were made with tropical kudzu (*Pueraria phaseoloides*), one of the best and most widely tested cover crops at this station.

PHYSIOLOGICAL STUDIES

By Arnaud J. Loustalot, Emery A. Telford,[20] and Carlos F. Cernuda

Acid medium favored kudzu growth.—Although tropical kudzu (*Pueraria phaseoloides*) appears to be generally well adapted to the climate and soils of Puerto Rico, little or no information is available as to its soil, mineral, and pH requirements. A series of greenhouse experiments were initiated in June 1946 to obtain data on some of these factors.

[20] U. S. Soil Conservation Service.

Most Temperate Zone legumes are favored by a weakly acid or neutral soil reaction. Many of the upland soils on which tropical kudzu may be grown in Puerto Rico are acid in reaction with a pH as low as 4. To determine the range of pH over which tropical kudzu may be grown, the following greenhouse experiment was performed:

Three kudzu plants 3 months old were planted in 5-gallon crocks filled with silica sand. Bamboo stakes with sidearms were used as vine supports in each crock. A complete nutrient solution adjusted to a pH of 5.5 was supplied daily to all crocks for 1 month, after which the differential treatments were started. Five full nutrient solutions adjusted to pH 4.0, 5.0, 6.0, 7.0, and 8.0 were applied daily to the surface of the sand. After 4 months of treatment the plants at all pH levels had made satisfactory growth. However, the kudzu growing at pH 6.0, 7.0, and 8.0 showed symptoms similar to those caused by iron deficiency in other plants, although 6 p.p.m. of iron was supplied in the nutrient solution. In general, these plants were less vigorous than those growing at pH 4.0 and 5.0. The plants were harvested and records of the dry weights, top-root ratios, and number and size of root nodules were made. The percentage of total nitrogen in the leaves and vines was determined. The data are presented in table 10.

TABLE 10.—*Effect of pH on dry weight, top-root ratio, nodulation, and nitrogen content of tropical kudzu growing in sand culture in the greenhouse*

Treatment *pH*	Average dry weight per plant	Top-root ratio	Total nitrogen in tops	Root nodules	
				Relative	Approximate
	Grams		*Percent*	*Size*	*Number*
4	78.3	9.4	2.37	Medium	Moderate.
5	80.0	6.3	2.08	Medium-large	Numerous.
6	72.0	5.0	2.08	Medium	Moderate.
7	73.0	6.0	1.90	Small	Few.
8	78.0	5.0	1.80	do	do.

It is evident that under the conditions of this experiment there was no marked or consistent trend in dry weight among the plants receiving the five pH treatments. Apparently the chlorotic leaf symptoms induced by the high pH solutions did not appreciably affect the formation of dry matter. There was no definite effect of pH on top-root ratio except in the case of the plants growing at pH 4, where the ratio was considerably higher than that of the four other treatments. This indicated that an acid soil reaction favors kudzu top growth. There was a definite correlation between the nitrogen content of the leaves and the pH of the nutrient solution. The plants grown in the low pH cultures had significantly more nitrogen than those grown in the high pH cultures.

Although the reaction of the growing medium had no appreciable effect on the dry weight of the plants, it appeared to influence the number and size of root nodules produced. In general, the nodules were larger and more numerous in the acid medium and were small and few in number at pH 7 and 8.

The results of this experiment and observations in the field indicate that tropical kudzu grows more or less satisfactorily over a rather wide

range of pH but it apparently grows best in an acid soil in the neighborhood of pH 5.5.

Mineral deficiency symptoms experimentally induced in tropical kudzu.—The purpose of this experiment was to produce experimentally deficiency symptoms of some of the essential mineral elements so that the disorder would be recognized if it occurred in the field. The tropical kudzu plants were grown in sand culture similar to that described in the previous experiment. Subequently, solutions adjusted to pH 5 and deficient in either calcium, potassium, magnesium, phosphorus, nitrogen, or boron were applied daily to the surface of the sand. A complete nutrient culture was maintained as a control.

The first plants to show deficiency symptoms were those receiving −K and −Ca solutions; the leaf pattern associated with low potassium was characterized by partial chlorosis or necrosis between the veins. The basal leaves were generally affected first and later the symptoms advanced toward the apex. Yellow areas appeared at the margins of the leaves between the veins and later extended inwardly in an irregular series of patches. Often the entire margin of the leaf was chlorotic and subsequently necrotic.

Calcium deficiency symptoms were characterized by rotting of the root system. The chlorophyll in the leaves faded along the margins and between the main veins and the green color was replaced by a buff pigment around the midrib. The area immediately adjacent to the main vein was unusually dark green. The leaves dropped before they became necrotic.

The plants supplied with −P solution did not develop definite deficiency symptoms until 2 months after the treatment started. At that time some of the basal leaves turned yellow, then light brown, and dropped. In general, these vines were less vigorous than those receiving the complete nutrient solution.

The plants receiving −Mg and −N solutions showed no deficiency symptoms.

After 4 months of treatment the plants were harvested and data on dry weight, top-root ratio, nodulation, and percentage nitrogen in the vines were obtained. The plants receiving the complete nutrient solution made the best growth as measured by dry weight. Tropical kudzu growing in solutions lacking phosphorus, potassium, and magnesium produced about the same amount of dry matter but somewhat less than that of the full nutrient plants. Of these treatments, −K was the only one in which the plants showed severe deficiency symptoms. This indicated that potassium deficiency, at least in the early stages, did not have a profound effect on the elaboration of dry matter. The dry weight of the −Ca plants was only a little over half that of the complete nutrient plants. An interesting feature of this experiment is the fact that both −B and −N plants showed no deficiency symptoms and appeared normal and vigorous, but the production of dry matter was profoundly depressed in both cases as a result of the deficiency, particularly in the case of nitrogen deficiency. This is in spite of the fact that the plants were all well nodulated at the time the experiment was started and there were large nodules on the roots of the −N plants when they were harvested. These results are in agreement with observations in the field where slow growth was noted in newly planted areas where nitrogen fertilizer was not applied.

Deficiency of phosphorus in most plants usually results in a sparse root system and a high top-root ratio. In this experiment with tropical kudzu the phosphorus-deficient plants had abnormally large root systems (the largest of all the treatments) and consequently the top-root ratios were small. The −N and −K plants also had large root systems in proportion to the tops. Boron deficiency apparently depressed root development because the amount of root produced was the smallest of any of the treatments, resulting in a high top-root ratio.

There were some interesting effects of the mineral deficiencies on the size and number of root nodules produced. The roots of both the −N and −K plants had abnormally large nodules which were moderately numerous as compared with those of the complete nutrient plants which were medium large and numerous. The nodules on the roots of the −Mg plants were somewhat smaller and less numerous than those of the complete nutrient plants. The −Ca and −B plants both had small nodules. Those on the −Ca plants were moderately numerous but many of them were decayed as were the fibrous roots. There were very few nodules on the −B roots.

Another interesting feature of this study was the fact that the large mass of roots in the −P treatment had very few nodules and those present were unusually small. It is evident that an adequate supply of phosphorus is necessary for good root nodulation of tropical kudzu. There was no appreciable difference among the treatments in the nitrogen content of the vines.

Phosphorus fertilization beneficial to tropical kudzu in poorly drained Mucara soil.—Some difficulty has been experienced in obtaining good stands of tropical kudzu on certain soil types in Puerto Rico, such as Mucara clay. Since this soil type comprises a good portion of the land on which tropical kudzu may be grown, it seemed worth while to investigate the difficulty.

The Mucara soil used in this experiment was excavated from a hole 6′×6′×3′ and brought to the greenhouse where it was spread out and allowed to dry, then thoroughly mixed. The pH of the soil was 4.6. Sufficient hydrated lime was added to half of the soil to raise the pH to 6.6. The plots consisted of 20 concrete receptacles 18″×18″×6″ with drainage holes in the bottom. Ten plots were filled with unlimed soil and the other 10 with limed soil. Each plot was planted with four 3-month-old tropical kudzu plants. Bamboo stakes with side-arms were used as vine supports.

Differential treatments were established 3 weeks after transplanting. Each group of 10 limed and 10 unlimed plots was divided into two subseries, each containing 5 plots of well-drained soil and 5 plots of poorly drained soil. Poor drainage was attained by plugging the drainage holes with cork stoppers and subsequently flooding the plots so that free water stood on the soil surface at least one-third of the time. The well-drained plots were watered as needed. Each subseries received fertilizer treatments applied to the surface of the soil as follows: (1) Phosphorus at the rate of 100 pounds P_2O_5 per acre; (2) potassium at the rate of 150 pounds muriate of potash per acre; (3) phosphorus and potassium at the rate of 100 pounds P_2O_5 and 150 pounds muriate of potash per acre; (4) boron at the rate of 20 pounds boric acid per acre; and (5) check. The plants were about 5 months

old when the treatments were started, and were under treatment about 3 months before they were harvested.

The dry weight data showed that the plants in the well-drained plots made better growth than those in the poorly drained plots. The only exception to this occurred in the poorly drained plots to which phosphorus was applied. The plants in the limed plots in general made somewhat less growth than those in the unlimed ones except as mentioned above.

Of the fertilizer elements, the best response was obtained where phosphorus was applied either alone or in combination with potassium. The outstanding feature of this experiment was the highly beneficial effect of phosphorus applications in the poorly drained plots. Tropical kudzu in these plots made excellent growth in spite of the fact that the roots were submerged in water a good portion of the time. Plants in poorly drained plots which did not receive phosphorus were chlorotic and made little growth. In plots with good drainage the response to phosphorus was best in the unlimed soil, but in the poorly drained soil the best growth was obtained where lime was applied. Potassium fertilization alone gave no better growth than that on the check plots. However, when potassium was applied with phosphorus in well-drained unlimed soil, the growth of the plants was the best.

Total nitrogen content of the stems and leaves from plants in all treatments are presented in table 11. In general, total nitrogen in plants from the well-drained plots was significantly higher than in plants from the poorly drained series. There was no appreciable difference in the nitrogen content of plants from limed or unlimed plots. However, in the poorly drained plots, fertilization with phosphorus resulted in higher nitrogen accumulation than in plants from other treatments. This indicates that phosphorus is essential to nitrogen fixation or assimilation with tropical kudzu. It also shows that phosphorus fertilization is particularly beneficial to tropical kudzu on poorly drained Mucara clay soil. Boron and potassium had no consistent effect on nitrogen content of the vines.

TABLE 11.—*Nitrogen content of tropical kudzu vines growing in soil in the greenhouse under different soil treatments*

Treatment	Good drainage		Poor drainage		Average
	Without lime	With lime	Without lime	With lime	
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
PK	2.44	2.32	2.05	1.97	2.19
P	2.27	2.22	2.15	1.98	2.18
K	2.04	2.42	1.84	1.41	1.93
B	2.11	2.13	1.68	1.55	1.87
CK	2.25	1.86	1.68	1.73	1.88
Average	2.22	2.29	1.88	1.73	

Chlorosis in tropical kudzu associated with low K/Ca ratio.—In some farming areas tropical kudzu does not grow vigorously and many of the leaves have an interveinal chlorosis which becomes more intense with age. Foliar analysis has proved to be a valuable aid in the diagnosis of mineral disorders of other plants and this technique was tried here.

Samples of normal appearing leaves and chlorotic leaves from the same field of tropical kudzu were taken at two different locations, one at Guajataca on the north coast, and the other at Maricao, in the interior of the island. Samples of leaves were also taken from experimental plots located at the station.

The leaf samples were analyzed for total ash, nitrogen, phosphorus, potassium, calcium, and magnesium. The levels of nitrogen and phosphorus in all the samples were generally high and more or less uniform. In no instance was the chlorosis associated with low values for these elements. On the other hand, there were considerable differences among the samples in the levels of potassium, calcium, and, to a lesser degree, magnesium. Low magnesium values alone were not associated with the chlorosis, since some samples having low magnesium did not show any deficiency symptoms. This was also true for the levels of potassium or calcium alone. The deficiency symptoms occurred in some samples when both potassium and calcium were high. In every instance where the K/Ca ratio was less than unity the leaves showed the interveinal chlorosis and where the ratio was higher the leaves appeared normal. Although trials have not been made, applications of potassium fertilizers to the chlorotic areas should theoretically correct the disorder.

Tropical kudzu increased value of grasses when grown together.—In May 1946 plots 15 feet by 30 feet of "gramalote" (*Panicum maximum* Jacq.), Napier grass (*Pennisetum purpureum* Schum.), Napier-millet hybrid, and "malojillo" grass (*Panicum purpurascens* Raddi) were planted alone and in combination with tropical kudzu. In October, 5 months after planting, the plots were harvested and data on relative yield and composition of the various grass and tropical kudzu plots were obtained. The data are presented in table 12.

TABLE 12.—*Yield per acre and composition of grasses grown alone and with tropical kudzu*

Grass	Yield		Composition						
	Fresh weight per acre	Dry weight per acre	Ash	Calcium	Magnesium	Potassium	Phosphorus	Nitrogen	Crude protein (N×6.25)
	Pounds	*Pounds*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Napier-millet hybrid	59,290	24,249	11.02	0.25	0.33	1.32	0.34	0.53	3.29
Napier-millet hybrid and tropical kudzu	61,105	11,878	9.98	.37	.39	1.70	.44	.86	5.38
"Gramalote"	43,560	11,878	10.01	.21	.37	1.58	.24	.69	4.32
"Gramalote" and tropical kudzu	44,770	9,997	10.94	.96	.65	2.49	.33	2.04	12.75
Napier	41,140	10,926	12.51	.25	.34	1.69	.39	1.20	7.50
Napier and tropical kudzu	55,660	14,994	8.64	.78	.53	1.87	.30	1.83	11.42
"Malojillo"	16,940	3,567	9.59	.17	.12	1.53	.38	.94	5.87
"Malojillo" and tropical kudzu	41,140	7,808	7.05	.69	.44	1.74	.33	2.00	12.90

The yield of fresh forage material was greater in all plots where tropical kudzu was grown with the four different grasses. However, on a dry-weight basis, the yield of the grass-kudzu plots was less with Napier-millet and gramalote, but Napier and malojillo yielded more dry matter when grown with tropical kudzu than when grown alone.

When tropical kudzu was grown with the four grasses, the quantity

of calcium, magnesium, and potassium in the grass-kudzu mixture was markedly increased over that of the grasses grown alone. The amount of phosphorus was increased in the case of the Napier-millet-kudzu combination and in the gramalote-kudzu mixture, but in the Napier- or malojillo-kudzu mixture the phosphorus was somewhat reduced.

The nitrogen and protein content of the mixture consistently increased in all cases where kudzu was grown with the grasses. In the Napier-millet-kudzu combination the increase was relatively small, but in the three other grasses the nitrogen and protein content of the kudzu-grass mixture was two to three times as great as in the grasses grown alone. These data are given in table 12.

It is apparent from this preliminary experiment that the yield and nutritive value of some grasses such as malojillo and Napier and gramalote may be increased by planting tropical kudzu with them. Feeding this enriched forage mixture to livestock may reduce the need for expensive imported concentrates and also increase milk and meat production.

WEED CONTROL

By David G. White and José C. Mangual

2,4–D killed only basal bulbs of nutgrass.—In preliminary tests with 2,4–D (2,4–dichlorophenoxyacetic acid) the ultimate effects on nutgrass (*Cyperus rotundus*) were inconclusive because new leaves appeared a few weeks after the death of treated leaves. To ascertain the specific effects of 2,4–D and other herbicides on nutgrass, individual tubers were germinated in test tubes containing soil. The following herbicides were applied with an atomizer on 5 to 10 plants: (1) 0.10 percent 2,4–D,[21] (2) 0.15 percent 2,4–D, (3) 0.15 percent 2,4–D in a 10-percent glycerin solution, (4) 0.15 percent 2,4–D plus 0.8 percent sodium chlorate, (5) 1.0 percent arsenic trioxide as Penite 6, and (6) 6.0 percent fuel oil emulsion fortified with 0.25 percent 2,4-dinitro-6-secondary butyl phenol. The first four treatments with 2,4–D caused the leaves to die within 2 weeks after spraying and the individual tubers were apparently killed. The addition of glycerin or of sodium chlorate did not cause more rapid killing than 2,4–D alone. Penite 6 and fortified fuel oil emulsion caused death of the leaves within 2 to 3 days after application, but new leaves soon appeared from the tubers.

Further trials were made with nutgrass grown from tubers planted in sand in V-shaped glass-sided boxes. Three boxes were planted with 20 tubers each. All leaves growing in an individual box were treated as a unit, using 0.15 percent 2,4–D at 2, 3, and 4 weeks, respectively, after planting. The root systems of plants sprayed 2 and 3 weeks after planting were decayed within 5 to 6 weeks after spraying, as viewed through the glass sides. Subsequent examination showed that no new tubers had developed and the 20 original tubers were completely decayed. In the box which was not treated until 4 weeks after planting, 7 new tubers developed, making a total of 27. Of these 25 were in a state of decay and 2 were apparently unaffected. These 2 live tubers appeared to be new ones which had developed from lateral rhizomes of the original tubers. Five new tubers which were decayed apparently developed from the vertical rhizomes below the original

[21] The sodium salt was used in all 2,4–D spray mixtures (Dow A–510).

tubers. This may be evidence that 2,4–D was translocated vertically in lethal quantities but not horizontally.

Thirteen applications of herbicides failed to eradicate nutgrass.—A field experiment was conducted in which 6 different herbicides were applied once each week on heavy stands of nutgrass. Each of the 7 plots, one a check, were 20 by 40 feet. The herbicides used were: (1) 10 percent Diesel oil emulsion fortified with 0.25 percent, 2,4–dinitro-6–secondary butyl phenol, (2) 10 percent Diesel oil emulsion fortified with 0.7 percent pentachlorophenol, (3) undiluted Diesel oil carrying 0.1 percent of the butyl ester of 2,4–D, (4) 0.15 percent 2,4–D as the butyl ester, (5) 0.15 percent of 2,4–D as the sodium salt, and (6) a 1-percent As_2O_3 as Penite 6, but since this herbicide had little effect the treatment was changed to undiluted Diesel oil for the last 10 applications.

No treatment reduced the population of nutgrass to a point of eradication. So long as a few tubers remained alive, they were a source of infestation. All weeds and grasses except nutgrass were eradicated by sprays 1, 2, 3, and 6.

"Cohitre" can be safely hoed 24 hours after spraying with 2,4–D.—Several plots 5 feet wide and 20 feet long, heavily infested with cohitre, were sprayed with 0.1 percent 2,4–D as the sodium salt and thereafter hoed at ½, 1, 4, 6, 12, 24, and 48 hours after spraying. It was found that cohitre hoed 24 and 48 hours after spraying with 2,4–D did not recuperate. The results indicated that the 2,4–D acts on the cohitre within 24 hours after application in Puerto Rico and that cultivation can be performed after that time without danger of the cohitre recovering.

2,4–D sprayed on lower third of "bejuco de puerco" was lethal.—In sugarcane plantations bejuco de puerco, *Ipomaea* sp., a vine which coils around cane stalks, interferes with growth as well as with the harvesting procedure. This weed is easily eradicated with 2,4–D but spraymen spend considerable time and material in attempting to completely cover each vine. A greenhouse experiment was performed on bejuco de puerco planted in individual cans and trained on bamboo stakes to a height of 6 feet or more. Plants were sprayed in groups of five with 0.1 percent 2,4–D (sodium salt) as follows: (1) Entire plant, (2) upper third, (3) lower third, (4) lower two thirds, and (5) controls, not sprayed. Within 2 months all plants except the controls and those sprayed on the upper third were totally dead; in fact the lower two-thirds of the latter plants were alive for some time afterward. Spraying the lower third of bejuco de puerco with 2,4–D resulted in kill of the entire plant and it is thus a waste of time and spray material to try to cover the whole plant.

2,4–D increases herbicidal action of Concentrate 40.—An experiment was conducted to determine the effects of Concentrate 40 plus 2,4–D on grasses as compared with Concentrate 40 alone. An area completely covered with Bermuda grass (*Cynodon dactylon*), a weed grass which is unaffected by 2,4–D and resistant to arsenicals, was divided into 10 equal plots. Five plots were treated with Concentrate 40 at 0.42 percent concentration of arsenic trioxide and 5 were treated with 0.10 percent sodium salt of 2,4–D in Concentrate 40 at the rate of 175 gallons per acre. Two uniform applications of both spray treatments were made at 4-week intervals and the results recorded

20 days after the last application. The addition of 2,4–D to Concentrate 40 increased its herbicidal action against Bermuda grass by 50 percent. Plots sprayed with Concentrate 40 alone were completely covered with weeds, 60 percent Bermuda grass, and 40 percent nutgrass. In those areas where the Bermuda grass was killed, an infestation of nutgrass replaced it. On the other hand, plots sprayed with 0.10 percent 2,4–D in Concentrate 40 were covered with only 40 percent Bermuda grass and 5 percent nutgrass, with the remainder of the area free of any weeds.

The results indicated that 2,4–D possibly activated the constituents in Concentrate 40 or vice versa with a resulting synergistic reaction. The increased herbicidal effectiveness of the combination sprays may also be due to the injury caused by the constituents of Concentrate 40 (arsenic trioxide, Santobrite, and sodium chlorate) which enables the 2,4–D to enter the plant and exert its physiological effect.

2,4–D liquid spray more effective in weed control than 2,4–D dusts.—Many sugarcane growers in Puerto Rico are using 2,4–D solutions in their weed-control program. 2,4–D dusts have not been used locally for this purpose. An experiment was conducted to determine the relative effectiveness of five different 2,4–D dusts and 2,4–D liquid sprays in the practicability of their use for weed control in sugarcane. The treatments were as follows: (1) 5 percent 2,4–D acid with cohuta talc; (2) 5 percent 2,4–D acid and an equal amount of soda ash with talc; (3) 5 percent 2,4–D in the form of Chipman 2,4–D spray powder plus 2 percent oil; (4) 5 percent 2,4–D in the form of Chipman spray powder plus 2 percent of a hygroscopic agent substituted for oil; (5) 10 percent 2,4–D in the form of Chipman spray powder with talc; and (6) 0.10 percent 2,4–D liquid spray.

An area of approximately 1¾ acre, planted to sugarcane and heavily infested with cohitre or dayflower (*Commelina longicaulis*) and bejuco de puerco was selected. This area was divided into plots one-fortieth of an acre in size. Five plots were used for each herbicidal treatment and rows 20 feet wide were left untreated between plots as a buffer. Dusts were applied with a hand duster between 6:00 and 8:00 a. m. There was no breeze on the day the treatments were made and the weeds were moist with dew. The 2,4–D spray was applied with a knapsack sprayer between 10:00 and 11:00 a. m. on a clear day with the air temperature at 87° F. Observations were made 20 days after the first application.

The 2,4–D liquid spray was more effective in controlling the weeds and less expensive than any of the dust treatments. All of the 5-percent 2,4–D dust treatments applied at a rate of 20 pounds per acre were more effective than the 10-percent 2,4–D dust applied at the rate of 10 pounds per acre.

Six herbicides gave promising results for sugarcane plantations.—Many sugar growers in Puerto Rico are using 2,4–D preparations and arsenicals as herbicides. In general, they have practically eliminated "cohitre" and "bejuco de puerco" with 2,4–D. However, elimination of these weeds as major pests was followed by increased stands of grasses and other weeds resistant to 2,4–D. Arsenic as in Penite 6 and as in activated Penite 6 (Concentrate 40) is being employed to aid in the control of weeds not killed by 2,4–D. Arsenicals have several disadvantages; they are poisonous, cumulative in the

soil, irritating to the skin, and are easily washed off the foliage by rains.

On the basis of preliminary trials made in canefield ditches, it was decided to compare the effectiveness and costs of various herbicides with the standard weed-control method of hand-hoeing in Puerto Rico. In cooperation with Mr. Owen Proverbs, manager of the Sucesión de Mateo Fajardo Cardona, 1¼ acres of the P. O. J. 2878 variety of sugarcane planted September 1, 1946, was divided into 50 one-fortieth-acre plots. Each treatment was replicated five times in plots arranged in a modified Latin square. The treatments and their cost are listed in table 13.

In addition to the treatments listed in the table, five plots were hand-hoed as controls, another five plots were treated with one of the above preparations which seemed best in relation to weed development. This is listed as "Changeable" in the table. The first spray applications and hoeing were done on a clear day, September 30, from 9:00 a. m. to 3:00 p. m. following a day without rain; the second on October 25, and the third on December 4, all at about the same time of day. The cane height in each case was respectively, 6–8 inches, 16–20 inches, and about 3 feet.

The relative population of weeds was recorded on January 4, one month after the third treatment, and these are presented in table 13.

TABLE 13.—*The average cumulative costs of herbicides applied on September 30, October 25, and December 4, 1946, and the relative population of weeds on January 4, 1947*

Treatment	Cost per 100 gallons of spray	Rate per acre	Labor per acre	Accumulated cost per acre [1]	Relative population of [2]—			
					Cohitre	Bejuco	Nutgrass	Others
	Dollars	*Gallons*	*Hours*	*Dollars*				
Hand-hoed			62:40	29.92	xxxx	xxx	x	x
2,4-D (0.1 percent amino salt) [3]	2.10	104	5:20	15.29	0	0	x	xxxx
Penite 6 (0.84 percent As_2O_3)	1.00	192	10:40	17.47	x	x	x	xxx
Concentrate 40 (0.42 percent As_2O_3, activated)	2.00	176	10:40	22.46	x	x	x	xxx
Concentrate 40 and 2,4-D	4.10	112	5:20	28.07	0	0	x	x
Dow Contact Herbicide (5 percent) [4]	11.24	112	5:20	64.55	0	0	0	x
Oil and butyl phenol [5]	6.74	112	5:20	39.82	0	0	0	x
Oil (10 percent) fortified with Santophen (0.7 percent) [6]	2.62	152	10:40	23.07	x	x	x	xxx
Oil, Santophen, and 2,4-D	4.72	128	8:00	33.11	0	0	x	xxx
Changeable (oil and butyl phenol) [7]		132	8:00	35.58	0	0	x	xxx

[1] Labor calculated at 25 cents per hour and cost of materials and first 2 treatments added.
[2] xxxx— heavy; xxx—moderate; xx—light; x—very few.
[3] On October 25, 2,4-D plots were hand-hoed.
[4] Contains 2,4-dinitro-6-secondary butyl phenol. Used oil and butyl phenol in third application because of insufficient Dow Contact Herbicide.
[5] 6 percent Diesel oil emulsion fortified with 0.25 percent 2,4-dinitro-6-secondary butyl phenol.
[6] Pentachlorophenol.
[7] Used 2,4-D on first application and oil and butyl phenol for the others.

It will be noted that the greatest populations of "cohitre" and "bejuco de puerco" were growing in the hand-hoed plots. In all other plots few if any of these weeds were present but various grasses developed in some. The chief grasses present were: Para grass ("malojillo"), *Panicum purpurascens* Raddi; Bermuda grass ("yerba Bermuda"), *Cynodon dactylon* (L.) Pers.; and wire grass ("Pata Gallina"), *Eleusine indica* (L.) Gaertn. In most cases these grasses were

mature and therefore a source for increasing the weed population. However, the plots sprayed with Concentrate 40 plus 2,4–D, Dow Contact Herbicide, and oil emulsion fortified with the butyl phenol all had considerably less grass than other plots.

Thirty-four days after the third application of herbicides all plots were hand-hoed to eradicate the remaining grasses. Another hoeing was necessary on March 5, 1947. The relative stand of weeds and the average cost of hand-hoeing all plots, and the total accumulative costs of treatments by March 5, 1947 are presented in table 14. By this time the sugarcane was 5 to 6 feet in height and further need for weed control was not anticipated until after harvest about 1 year later.

TABLE 14.—*The relative stand of weeds and total accumulative costs of treatments on March 5, 1947*

Treatment	Accumulated cost of treatment [1]	Relative stand of weeds			
		Cohitre	Bejuco	Nutgrass	Others
	Dollars				
Hand-hoed	42.04	xxxx	xx	x	x
2,4–D alone [2]	23.19	0	x	x	xx
Penite 6 [3]	21.26	x	x	x	xx
Concentrate 40 [4]	26.93	x	x	x	x
Concentrate 40 and 2,4–D [4]	35.32	0	x	x	x
Dow Contact [4]	66.46	0	0	x	x
Oil and butyl phenol [4]	42.23	0	x	x	x
Oil and Santhophen [2]	29.43	x	x	x	xx
Oil, Santophen and 2,4–D [2]	38.25	0	0	x	xx
Changeable [2]	42.77	x	x	x	xx

[1] Includes total labor for hoeing, spraying, and materials.
[2] 3 plots needed hoeing; labor calculated at 25 cents per hour.
[3] 2 plots needed hoeing.
[4] Only ditches needed hoeing.

In this experiment the use of herbicides in sugarcane was found to be more effective in suppressing weed development than hand-hoeing and in most cases it was less expensive. The laborers worked under close supervision so that the actual cost of labor per acre on a plantation basis would be somewhat higher for all treatments. However, the costs recorded here give some idea of the relative expense of cultivation under the various treatments. One item of cost not included was that of equipment which would vary according to the original price, its quantity, and subsequent care. The oil emulsion sprays also have an added expense for machinery and time to prepare the stock emulsions.

The results show that the 2,4–D is outstanding in eliminating certain broadleaf weeds, such as "cohitre" and "bejuco de puerco," but it is not sufficiently effective for complete weed suppression. The addition of 2,4–D to Concentrate 40 in particular, and to some extent in an oil emulsion fortified with Santophen, resulted in greater suppression of all weeds than either of the nonselective herbicides used alone. However, Penite 6, Concentrate 40, and oil emulsions fortified with Santophen all have the disadvantage of irritating the skin. Large-scale use of these materials usually requires special protection of the spraymen with rubber boots, gloves, and padding on the back and chest. This extra equipment is hot, burdensome, and costly.

The results with the "Changeable plots" which were first sprayed

with 2,4–D and later with an oil emulsion fortified with the butyl phenol are of interest. They emphasize the necessity of suppressing grasses and other weeds not affected by 2,4–D in their early stages of development. If such weeds are once allowed to become well established, their suppression is difficult at a later date with the usual concentrations of herbicides. Therefore, the first application of a herbicide in sugarcane should be done thoroughly while the weeds are still small.

The two most satisfactory controls were Dow Contact Herbicide and an oil emulsion fortified with the butyl phenol. These sprays were also the most expensive although the third application was not actually necessary. It is felt that possibly the thorough suppression of weeds by this type of herbicide may have a lasting effect and thereby reduce weeding considerably in succeeding cane crops. The Dow Contact Herbicide has the advantage of being already prepared by the manufacturer for easy mixture in the field. The oil emulsion, on the other hand, requires time and machinery for preparation by the cane grower. Both of these are less poisonous than arsenicals, do not accumulate in toxic amounts in the soil, and are nonirritating to the skin of workers.

Although some of the lower leaves of the sugarcane plants were burned by the nonselective herbicides, this damage was not extensive and apparently did not noticeably limit growth 4 months after treatments started.

Frequently an insufficient number of men are available on cane farms to perform weeding at the proper time. Throughout this experiment about 162 man-hours per acre were required to hand-hoe the plots not treated with a herbicide. In contrast, about 35 man-hours per acre were required for Dow Contact Herbicide, oil emulsion fortified with the butyl phenol, and Concentrate 40 plus 2,4–D treatments. Thus, these herbicides resulted in much better weed suppression with less than one-fourth the man-hours of labor used for hand-hoeing.

Waterfern pest killed with fortified oil emulsions.—The ponds and irrigation reservoir of the station became densely and quickly covered by a small aquatic fern, *Salvinia rotundifolia* Willd. One application of 6 percent pentachlorophenol or 0.25 percent 2,4–dinitro-6–secondary butyl phenol almost completely eradicated the plant. "Spot" applications at 3- to 5-month intervals were necessary to hold the pest under control. Application of 2,4–D did not affect this weed.

Procedure established for preparing herbicidal soil emulsions.—Considerable difficulty was encountered at first in preparing herbicidal emulsions at this station. The following procedure has been found dependable for preparing a stable stock solution of a Diesel oil emulsion when using a 50-gallon power spray rig: Disconnect the tank agitator and place 12 gallons of water in the tank. Start the pump at a pressure of at least 150 pounds. Add 10 gallons of Diesel oil slowly while the mixture is pumped back into the tank through the spray nozzle. After mixing for about 15 minutes, add ½ pound of Oronite Wetting Agent or similar material. Then add the desired amount of fortifying agent and continue agitation until the oil and water do not separate. Stop the pump and bring the volume to 25 gallons with water. Mix again for a few minutes and the resulting stable emulsion is sufficient for 100 gallons of spray containing 10 percent oil.

ENTOMOLOGICAL STUDIES

DDT INVESTIGATIONS

By Harold K. Plank

Service test was begun to compare DDT and pentachlorophenol as termite repellents.—To avoid damage to many kinds of woods by termites, a number of chemicals have been used from time to time with variable success and adaptability. In comparatively recent years pentachlorophenol at 5 percent in a fuel oil of the Diesel type has been found suitable for protection from termites, and from decay, under both indoor and outdoor conditions (*4, p. 3; 8, pp. 624, 625; 25, pp. 11–13*). In experiments that have been under observation for nearly 3 years, Wolcott has found that samples of susceptible wood soaked for 10 minutes in 2-percent solutions of pentachlorophenol and DDT in benzol have thus far remained unattacked by the common dry-wood termite (*Kalotermes* (*Cryptotermes*) *brevis* Walker) (*72, p. 126*).

Present construction of seven concrete houses of identical design on the station grounds made possible a convenient comparison of the termite-repelling qualities of these two materials under actual service conditions. All of the interior and all but one unit of the exterior woodwork of these buildings was treated by the unheated dipping method. The treated woodwork consisted of paneled and louvered doors with attached jambs and louvered windows with their frames, all made of planed and sanded longleaf pine. The time from installation to first evidence of infestation by termites over the next 10 years or more is to be used as the principal criterion of effectiveness. This report records the method of formulation, the quantity of materials used, and the time employed in their application.

A locally purchased Diesel fuel oil having a specific gravity of 0.834 at 27° C. was used as the principal solvent. An approximately 5-percent solution was made of pentachlorophenol and a 2-percent solution of DDT. Since pentachlorophenol is soluble in fuel oil to the extent of only about 3 percent at 20° C. (*8, p. 623*), soluble pine oil had to be used as an auxiliary solvent. No such difficulty was encountered with DDT. To prevent blooming, or surface recrystallization, of both compounds on drying, a small quantity of lubricating oil, SAE–30, was included in both formulas, as follows:

To make 50 gallons of pentachlorophenol treating solution, 17 pounds of pentachlorophenol were first dissolved to saturation in 3 gallons of soluble pine oil by agitation for several days. These ingredients and 2 gallons of lubricating oil were then added to a 55-gallon drum containing 44 gallons of Diesel fuel oil. After 3 days of intermittent agitation by rolling all the pentachlorophenol was dissolved.

To make 50 gallons of DDT treating solution, 7 pounds of DDT were added directly to a 55-gallon drum containing 47.5 gallons of Diesel fuel oil and 2 gallons of lubricating oil. Dissolution was complete after a few hours of intermittent agitation.

Pentachlorophenol was applied to half the doors and jambs used on the interior and on the service porch of each house. With the treating solution unheated, each unit was dipped for 3 minutes and then allowed to drain for 6 minutes, 3 minutes on each side. All cut and retrimmed ends, planed surfaces, and nail or other holes made during

installation were retreated by liberally brushing or injecting with the treating solution.

DDT was applied to the remaining units, that is, half of those used on the inside and on the service porch of each house. Application and retreatment were also the same as for pentachlorophenol, but the dipping time was 10 minutes and the draining time 5 minutes on each side.

Randomization of the treated units within any one house was left to the convenience of the contractor, and each unit with its corresponding treatment indicated was located on an appropriate diagram for future reference.

The average unit absorbed slightly more than 1 gallon of the pentachlorophenol solution and 1.5 gallons of the DDT solution. The average time used to dust, dip, drain, and pile each unit, including preparation of the dipping solution and cleaning the tank, was slightly less than 1 man-hour for each treatment. With this excellent absorption of both solutions it is important to record that penetration along the grain through crosscuts was noted in many instances to be more than 2 inches. Considerable quantities of solution were also taken up at the joints, which are the locations where insects and fungi are most apt to enter. The oiliness of the wood disappeared within 2 days and most of the oily "feel" within about 2 weeks after dipping. Paint applied at the end of this time appeared to dry and adhere as well as on untreated wood.

MISCELLANEOUS INSECTS

By Harold K. Plank and Pedro Seguinot Robles

DDT produced good control of bean insects.—Since DDT has been used successfully in the control of bean insects elsewhere (*56, pp. 1–2; 58, pp. 2–4*), it appeared desirable to try this material under field conditions in Puerto Rico. A commercial agricultural grade containing 25 percent of DDT in a wettable powder was used at the rate of 4 pounds in 100 gallons of water. For comparison, a commercial rotenone extract which was said to contain among other active ingredients, 2.5 percent of rotenone and which had previously given good control on a number of bean insects, was used at the rate of 1 gallon to 400 gallons of water; a commercial spreader-sticker was added at the rate of 8 fluid ounces per 100 gallons to increase wetting power. These materials were applied twice, August 22 and September 26, at the rate of about 200 gallons per acre to the Bountiful variety of field beans and the Fordhook 242 variety of bush lima beans. Each field was divided into 9 plots of 14 rows, or 0.027 acre, each to provide 3 replicates of each treatment and the check. At the time of the first application all plants were about a foot high; Bountiful was beginning to bush, and Fordhook 242 had produced tendrils. At the second application Bountiful was approaching maturity, and Fordhook 242 blooming had almost reached its peak. Neither material seemed to have any toxic effect on either variety at any time. Nine and one-half inches of rainfall on 19 days in August and 11.75 inches on 24 days in September caused the spread of a severe infection of anthracnose through both varieties; most of the crop on Bountiful was destroyed and Fordhook 242 failed to set any pods.

In spite of the fact that the DDT spray material formed a white

residue which persisted for several weeks after each application, the lasting qualities of actual DDT in the deposit were temporary. An analysis made 29 days after the first application, during which time 7.54 inches of rain had fallen, showed no DDT present on either variety. A similar analysis 1 day after the second application and 0.63 inch of rain showed no DDT on Bountiful pods, an average of 0.0011 mg. per square centimeter of leaf area on Bountiful, and an average of 0.0015 mg. per square centimeter on Fordhook 242. The fresh, unweathered deposit from a typical test application contained DDT in the amount of 0.13 mg. per square centimeter of leaf area on Bountiful and 0.12 mg. per square centimeter on Fordhook 242.[22]

There was never any great difference in the appearance of the plants that could be attributed to insect control, but the general absence of leafhoppers and leaf beetles from the DDT plots was noticeable, and the population of these insects did not increase for a week or 10 days after treatment with this material. The control of these and other insects was determined by examination of leaf samples at 8, 18, and 28 days after the first spray and 8 days after the second. The results of these examinations are summarized as follows:

The leafhoppers present on both varieties of beans were *Empoasca fabae* (Harr.) and *Agallia albidula* Uhl.,[23] mostly the former. About twice as many leafhopper nymphs were found on the untreated leaves of Bountiful as on Fordhook 242. Rotenone extract had a tendency to exert some control but not significantly so after 18 days on either variety. DDT quickly controlled the leafhoppers on both varieties and kept the infestation at an extremely low level.

Adults and nymphs of two species of thrips, *Leucothrips* sp. and *Sericothrips* sp.,[24] were found on the leaves of both varieties, but at each examination of the untreated plots, except the last, the number of thrips found on Bountiful was at least significantly greater than that on Fordhook 242. Under these conditions, rotenone extract failed to exert any significant control. However, where DDT was applied the reduction of thrips population was immediate and lasting.

Damage by leaf beetles was caused mostly by *Cerotoma ruficornis* although *Systena basalis* and other species may have been present. Damage by all combined was somewhat greater in the Bountiful variety than in Fordhook 242, but the difference was not significant. While rotenone extract tended to reduce damage, it failed to do so to any significant extent. DDT was somewhat more effective, producing significant reductions in leaf injury in both varieties 18 and 28 days after the first application. These reductions, however, would probably not be considered adequate.

Leaf webbers and tiers were present in both varieties of beans, but their injury was more noticeable in Bountiful. Although the larvae of several pyralids may have been responsible for damage, the species causing the most injury was *Hedylepta indicata* (F.). Larvae of *Brenthia* sp., probably *Pavonacella* Clem., family Glyphipterygidae, were also present in several samples of the Bountiful variety. There was a tendency in both varieties for both rotenone extract and DDT to reduce iujury by these insects below that on the untreated plants.

[22] These analyses were made by Caleb Pagán Carlo, using the method of Gunther (*20, p. 149*).

[23] Determined by P. W. Oman, Bureau of Entomology and Plant Quarantine.

[24] Determined by J. C. Crawford, Bureau of Entomology and Plant Quarantine.

However, rotenone extract did not produce a significant reduction on either variety, and DDT was effective only late in the experiment.

Toward the end of the experiment many sample leaves bore light to heavy infestations of mites, mostly a species of *Tetranychus* similar to *bimaculatus* Harvey.[25] Up to September 19, 28 days after the first application, less than 17 percent of the samples were found infested by mites, but at the next examination on October 4, 8 days after the second application, large numbers were found in both the untreated and the treated samples of the Bountiful variety. At that time 40 percent of the leaves in the check plots were infested, 7 percent of them heavily; 60 per cent of the rotenone-treated leaves were infested, 7 percent heavily; and 63 percent of the DDT-treated leaves, 23 percent heavily. Mite infestation on Fordhook 242 was much lighter. At the last examination no infested leaves were found in the untreated samples, 10 percent in the rotenone-treated, and 27 percent in the DDT-treated. Apparently neither treatment was effective in controlling mites; rather the indications are that mite infestation increased under both, but particularly where DDT was used.

BAMBOO PRODUCTION AND INDUSTRIALIZATION

PROPAGATION AND DISTRIBUTION

By David G. White and Roberto Ferrer Delgado

One new species of bamboo introduced.—Three plants of *Chimonobambusa quadrangularis* (Fenzi) Makino, P. I. No. 112744, and three plants of *Dendrocalamus strictus* (Roxb.) Nees, P. I. No. 424504, were received during the year. The number of bamboo species and varieties in the station collection now totals 35.

Additional bamboo planted on mountain watersheds.—As indicated in last year's report (*62, pp. 34–35*), the station has cooperated with the Insular Forest Service in a watershed protection program. The experimental planting above the Cidra reservoir of *Bambusa tulda* Roxb. made last year at distances of 15, 20, and 25 feet has developed well. During the year, 7,543 offsets of *B. tulda*, 11,283 of *B. tuldoides* Munro, and 4,353 of *B. longispiculata* Gamble ex Brandis were supplied to the Forest Service. In addition, 200 clump divisions of *B. tulda* were planted by the U. S. Army on military posts. Farmers in Puerto Rico received 1,260 clump divisions of *B. tulda*, 25 of *B. tuldoides*, 75 of *B. longispiculata*, 25 of *B. textilis* McClure, and 25 of *Dendrocalamus strictus*. Four clump divisions of *Sinocalamus oldhami* (Munro) McClure, 4 of *B. tulda*, and 4 of *D. strictus* were sent to the Institute of Inter-American Affairs in Haiti. Three clump divisions of *B. tulda* and 3 of *D. strictus* were sent to the Dominican Republic.

Local manufacturers using bamboo culms.—In cooperation with the Puerto Rico Industrial Development Co., 66,696 feet of *Bambusa tulda*, 5,720 feet of *B. tuldoides*, 1,678 feet of *B. longispiculata*, 228 feet of various bamboo species, and 2,394 pounds of bamboo side branches were distributed to local manufacturers, especially to the bamboo fishing-rod industry which was established last year.

Bamboo seed offers an easy and economical method of propaga-

[25] Determined by E. A. McGregor, Bureau of Entomology and Plant Quarantine,

tion.—A large quantity of seed of *Bambusa arundinacea* Retz. from the 1945 crop was planted at a depth of ¼ inch in a flat of soil within a greenhouse. After about 2 months the young plants were 8 to 10 inches in height and were transplanted to gallon cans and placed under partial shade. Eight months later each plant was 3 to 4 feet in height with numerous side branches and additional shoots. These were transplanted for a windbreak at 6-foot intervals along an irrigation ditch and immediately showed good growth. Six months later a dense hedge 10 to 12 feet in height had developed. These results show that a special effort should be made to induce flowering and seeding of bamboo and thereby reduce the present high cost of propagation.

Fertilization of bamboo offsets resulted in more culms and better growth.—In May 1944 offsets of 5 promising bamboo species were planted 25 feet apart on the square. One year later, 3 pounds of commercial fertilizer (12–10–6) were applied to alternate clumps. The fertilizer was placed in a shallow ditch circumventing each clump and covered with soil. This treatment was repeated in May 1946. During November 1946 the number of culms which had sprouted earlier in the year were counted and also the number of new shoots which had died in both the fertilized and check clumps. Generally not all of the shoots which arise develop into culms. In addition, the average diameter of 5 representative culms at 4 feet above the ground in each clump was measured except for culms of *Dendrocalamus strictus* which had a great number of interfering lateral branches. The average height of each clump also was measured with a hypsometer and the basal circumference of each clump was measured with a steel tape. The average measurements of 9 to 17 fertilized clumps and an equal number of check clumps of the 5 species are presented in table 15.

In all species more new shoots arose from fertilized clumps than from check clumps; also a higher percentage of the shoots developed into culms. The cost of the fertilizer used thus far would be more than covered by the value of the additional culms. No marked differences occurred between fertilized and check clumps in the average diameter of the culms, and the height and basal circumference of the clumps. In most instances the fertilized clumps of all species were much greener than the unfertilized clumps.

TABLE 15.—*The effect of fertilization on development of bamboo culms in 1946*

Species	Treatment	Shoots developed per clump		Average culm		Average clump circumference
				Diameter	Height	
		Number	*Percent* [1]	*Inches*	*Feet*	*Feet*
Bambusa longispiculata	Fertilized	13.4	61	1.48	28.7	16.9
	Check	10.2	53	1.48	27.7	16.9
Bambusa textilis	Fertilized	31.8	94	1.00	23.2	7.9
	Check	29.7	87	1.02	23.7	8.9
Bambusa tuldoides	Fertilized	26.8	97	.95	20.6	12.6
	Check	20.3	94	.95	20.0	11.8
Dendrocalamus asper	Fertilized	5.1	66	2.91	35.8	8.9
	Check	4.5	64	2.81	34.4	8.8
Dendrocalamus strictus	Fertilized	13.2	86	(2)	21.4	9.9
	Check	8.8	83		19.2	7.9

[1] Of the total number sprouted.
[2] Not measured.

Rooting of bamboo side-branch cuttings was practical with at least one species.—The possibility of propagating bamboo from side-branch cuttings was investigated with some success by Cobin (*18, pp. 30–31*) in 1944. A series of experiments was initiated during the past year to determine the possibility of propagating bamboo by side-branch cuttings. If efficient methods could be found, the cost of propagating bamboo by clump divisions (*61*) could be considerably reduced.

During December 1945 an experiment was started using side-branch cuttings taken from 2-year culms of 10 different bamboo species. Ten cuttings of each species were planted in sand without additional treatment. Other cuttings in groups of 10 of each species were treated with different root-promoting substances by the alcohol-dip method before planting. Treatments included: (1) 5 mg. of indole-3-acetic acid per milliliter of 50 percent alcohol; (2) 2 mg. of indolebutyric acid per milliliter; (3) 2 mg. of alpha-naphthylacetamide per milliliter; and (4) 0.1 mg. of 2, 4-dichlorophenoxyacetic acid per milliliter. The basal ends of the cuttings were dipped in the solution for 5 seconds and planted immediately in sand. Similar sets of cuttings were obtained and treated in March, June, and September 1946. On some cuttings roots have arisen from the foreshortened internodes at the base, usually accompanied by top development. On the other hand, some cuttings have produced new top growth but no roots.

In another experiment the rooting of side-branch cuttings of some species of bamboo was tried at 3-month intervals over a period of a year. Considerable variation in rooting occurred among species. Although no cuttings of *Bambusa tuldoides* and *Cephalostachyum pergracile* Munro rooted in any trial, about half of those of *Gigantochloa verticillata* (Willd.) Munro rooted, except when cut in September. *Sinocalamus oldhami* was the only species in which at least some cuttings rooted in all the trials. September appears to have been a particularly poor month for obtaining rooting in all species. With the exception of *B. textilis*, December or March were the best months for obtaining cuttings for rooting. The results of this experiment indicate that cuttings obtained during the dry months of December and March generally rooted better than those obtained during the rainy season.

Leafless side-branch bamboo cuttings grew best.—In March 1947 an experiment was started using both leafless and leafy side-branch cuttings of bamboo to determine the best type for rooting. The cuttings were obtained from culms 2 years old or older, and from the five most important and promising species: *Bambusa tulda*, *B. tuldoides*, *B. polymorpha* Munro, *B. longispiculata*, and *Sinocalamus oldhami*. Twenty-five cuttings of each species were used per treatment. The treatments were as follows: (1) Leafy cuttings dipped for 5 seconds in a 50-percent alcohol solution containing alpha-naphthylacetamide, 2 mg. per milliliter; (2) leafless cuttings treated as in (1); (3) leafy cuttings with no treatment; and (4) leafless cuttings with no treatment. All cuttings were planted in a sand bed immediately after treatment.

Three months after planting, all cuttings were making top growth except the leafy cuttings of *Bambusa tuldoides*, *B. longispiculata*, *B. polymorpha*, and *B. tulda*, regardless of treatment.

Cuttings of *Sinocalamus oldhami* were growing in all treatments

but the growth of the leafy cuttings of this species was less than that of the leafless. The "take" varied from 8 percent for *Bambusa tuldoides* to 100 percent for *S. oldhami* in the untreated check group. In all instances the treated cuttings made less growth than the untreated checks; the take varied from 4 percent for *B. tuldoides* and *B. longispiculata* to 96 percent for *S. oldhami*. The concentration of hormone used may have been too high and inhibited growth rather than promoted it.

In another experiment 817 cuttings of the same 5 species were planted in a bed of riverbank soil. Three months later it was apparent that these cuttings were growing better in this medium than those previously planted in sand. These cuttings were not treated with root-promoting substances. The fact that *Bambusa tulda* showed about 30 percent rooting under these conditions is of practical importance.

SEED STORAGE

By David G. White and Roberto Ferrer Delgado

Calcium chloride prolonged longevity of bamboo seed.—In last year's report (*67, p. 35*) an experiment in storage of seed of *Bambusa arundinacea* collected in 1945 was described. Seed of this species were available again in February and March of 1945 and additional storage treatments were investigated. The seed were stored in fruit jars except for one sample placed in a dessicator over a solution of potassium pyrogallate. Hydrated lime and powdered charcoal were used in addition to calcium chloride as drying agents. For controls, one sample of seed was exposed and another sample was sealed tightly in a jar without a drying agent. The original moisture content of the seed averaged 23 percent. Half of each sample was dried in an oven to a moisture content of 12 percent. Samples of seed at these two moisture contents were exposed to room temperatures ranging from 70° to 90° F. and to temperatures in a refrigerator ranging from 44° to 50°. The control seed and that over potassium pyrogallate were exposed to room temperature only. The initial germination of oven-dried seed averaged 79 percent and those not dried averaged 88 percent.

At the end of 72 days of storage, seed which had not been oven-dried had a higher percentage germination than seed which had been dried, although the differences were often small. After 148 days, seed stored at room temperature over hydrated lime, potassium pyrogallate, and sealed in jars without a drying agent did not germinate. Under the other conditions, four oven-dried samples had greater germination than seed similarly stored but not dried. After 227 days the greatest germination followed storage over calcium chloride at room temperature. Under these conditions the dried seed germinated slightly better. Refrigeration at 44° to 50° F. apparently did not increase the effectiveness of calcium chloride in prolonging viability. On the other hand, refrigeration of seed over hydrated lime and over charcoal increased longevity. A small percentage of the control seed exposed to room temperature germinated after 227 days.

As in the previous tests, it was found that the most practical method of preserving viability of bamboo seed was storage over calcium

chloride at room temperature. Storage over hydrated lime and over charcoal were also satisfactory if refrigerated. Drying of the seed to a moisture content of about 12 percent increased longevity when stored over hydrated lime under refrigeration. In other cases there was little or no advantage gained by initial drying when no drying agent was used in storage. Exposed seed retained viability longer than seed sealed airtight.

BAMBOO POWDER-POST BEETLE

SUSCEPTIBILITY TESTS

By Harled K. Plank and Roberto Ferrer Delgado

First-year culms of *Sinocalamus oldhami* were less susceptible than older culms to powder-post beetle attack.—During December and January, culms of *S. oldhami* that sprouted in 1941 to 1945 in well-established clumps were compared with corresponding culms of *Bambusa vulgaris* Schrad. ex Wendl. to determine the relative susceptibility of the two species to attack by the bamboo powder-post beetle (*Dinoderus minutus* (F.)). The usual testing procedure was followed as described in previous reports (*51, p. 43*). The combined test pieces of all ages of *B. vulgaris* sustained a total of 1,878 beetle attacks, or an average of 6.26 each, whereas those of *S. oldhami* sustained a total of only 119, or 0.40 attack each. This difference between species was highly significant and equivalent to an over-all susceptibility for *S. oldhami* of 6.3 percent.

The most striking fact brought out by this experiment was that, unlike any other species tested to date, *Sinocalamus oldhami* was practically immune to attack during its first 3 years of growth and somewhat more susceptible in its fourth and fifth years. In *Bambusa vulgaris*, the beetle attacks on the first 3 years' growth were uniformly high and the fourth and fifth years uniformly low, with no statistically significant difference between the first and third years. On the other hand, the order of beetle infestation in *S. oldhami* was reversed, but the number of attacks on any one year's growth was too low for any of the differences among ages to be significant. The fourth year's growth was attacked more than four times, and that of the fifth year more than seven times as much as the 1-year-old culms. The differences between the two species at all ages except the fifth were highly significant.

In *Bambusa vulgaris* there was the usual tendency for the base of the culms to be more heavily attacked than the middle, and the middle more than the top. In the second and fifth years the middle portion was attacked more than the base, but the difference was not statistically significant. The tops of the 4-year-old culms were attacked significantly more than the middle. In *Sinocalamus oldhami*, on the other hand, the middle internodes of all culms except those in their fourth year were attacked more than the base and the top scarcely at all, but in no year was the number of attacks sufficiently large to show any significance.

In general, the foregoing differences in beetle infestation were closely correlated with the starch content of the wood as indicated by the iodine spot test. In *Bambusa vulgaris* the base of most of the culms contained the most starch, the middle less than the base, and

the top somewhat less than the middle, regardless of age. With *Sinocalamus oldhami*, however, the base and top of all culms showed a lower starch content than the middle. Apparently, what little starch there is in this species is stored in the older culms and in parts other than the basal internodes.

CHEMICAL CONTROL

By HAROLD K. PLANK

Air-drying increased resistance of bamboo wood to attack.—Experiments in the control of the bamboo powder-post beetle (*Dinoderus minutus*) have indicated that certain chemicals may be employed to reduce or prevent attack. However, the chemicals found to be most effective either were too poisonous for general use or made the wood unsuitable for many purposes (*35, pp. 32, 38, 39; 47, p. 116*). Several other chemicals not having these objections were tested for protective qualities in conjunction with air-drying for periods up to 6 months.

Three-fourth-inch rings from 1-year-old culms of *Bambusa vulgaris* were dipped for 10 seconds in kerosene solutions of dinitro-ortho-cyclohexylphenol at 1 percent, pentachlorophenol at 1 and 2.5 percent, diphenylamine at 0.6 percent, and in kerosene alone. To permit the solvent to evaporate and some curing to take place, these and an equal number of untreated rings were kept in a ventilated beetleproof cage. At periods of ½, 1½, 3, and 6 months thereafter, equal numbers of rings of each treatment were removed and exposed to beetle attack. Dinitro-ortho-cyclohexylphenol was the only chemical dip which tended to keep the beetle infestation at a low level. The average control for all drying periods combined was 90 percent. Applied by brushing to half-length culm sections, none afforded any protection against the beetle.

An important fact revealed by these tests was a tendency for beetle attacks to decrease as the drying or curing time increased. Simply allowing the undipped bamboo to air-dry for 6 months before exposure to the beetle resulted in 83 percent fewer beetle attacks than air-drying for one-half month. Since these tests extended from January to July, the driest part of the year, it is possible that the extent of curing had some influence on the resistance observed. There was little difference in moisture content between one-half month of curing, 18.0 percent, and 6 months of curing, 16.7 percent. However, in the absence of corresponding starch tests, this curing may help to explain why some culms of otherwise susceptible species of bamboo have been frequently observed free from further infestation after the initial attack immediately following harvest. It may also explain the superior results secured from clump-curing, in which the culms are dried for a month or more in the field, where beetle infestation rarely occurs (*47, pp. 115–116*).

DDT gave excellent protection on freshly harvested culms.—To find a treatment that would protect whole culms during the curing process, other materials were tried that appeared to be more promising than the foregoing. Pentachlorophenol at 4 to 5 percent in kerosene and its sodium salt with sulfur, both at 2 percent in water, as used for *Lyctus* control in lumber (*13, 14*), and DDT at 5 percent in kero-

sene were applied by the brushing method. For each solution and the untreated check, five 1-year-old culms of *Bambusa vulgaris* that had been harvested 2 days previously were used. These culms were then stored in an open shed where all were equally accessible to the beetle. When examined 72 days after treatment, internodal infestation in the untreated culms was about as usual, namely 84 percent; the sodium pentachlorophenate-sulfur combination and increased-strength pentachlorophenol failed to cause any appreciable reduction. However, DDT at the residual-spray strength of 5 percent resulted in 94 percent less infestation than in the untreated. Both the base and upper part of all culms receiving this treatment reacted strongly to the iodine test for starch. In spite of this high concentration of starch, one entire culm and all but one basal piece of the four other culms remained free from infestation, and only from one to three internodes in the upper parts were attacked.

The characteristic white crystallization left by DDT was still plainly visible after 72 days, and dead beetles were still clinging around some nodes. Most of the few beetle entrances found were at the nodes where side branches had been trimmed off, but the majority of these holes were shallow, many still containing the beetles that died before they could bore more than a few millimeters into the wood. So far as could be detected without splitting, no internal infestation had developed, whereas in the check and other treatments, many culms were completely riddled. In this test DDT appears to be better than anything else thus far tried for protecting whole culms from insect attack during the critical months immediately following harvest (*54*).

STORAGE TESTS

By David G. White and Roberto Ferrer Delgado

Bamboo culms were resistant to powder-post beetles when stored under insectproof conditions for 6 months.—In December 1945 1-year culms of *Bambusa vulgaris* were cut and then clump-cured for 2 months. In February 1946 the culms were cut into 5-foot sections and randomized in bundles of 12 sections per treatment. One bundle was exposed to the bamboo powder-post beetle (*Dinoderus minutus*) in a storage shed as a check and the others were treated as follows: (1) Wrapped tightly in a double layer of heavy Manila paper, (2) wrapped tightly in a double layer of heavy Manila paper with moth balls distributed throughout the bundle, (3) placed in a tightly sealed wooden box, and (4) placed in a tightly sealed wooden box with moth balls distributed throughout the box. The treated bundles were also placed in the same storage shed where there was an abundance of beetles.

The first inspection was made in August 1946. All culms of the check bundle were heavily infested by the powder-post beetle. In addition, the Manila wrapping paper of treatments 1 and 2 was riddled with holes of the beetle and the culms of both bundles were heavily infested. It is of interest to note that the beetles sought out culms heavily wrapped in paper even though a considerable quantity of unprotected bamboo was available to them. In treatment 2 some of the moth balls used were still present but even these had no deterrent effect on the beetles. Culms within the sealed boxes were not infested.

Four sample culms from each box were removed for exposure and the remaining culms were repacked. Spot iodine tests indicated little if any starch present in the stored culms at this time. Six months later the culms stored in tight boxes with and without moth balls were not infested. Four culms from each box were then removed and exposed for 4 months. No subsequent infestation occurred. After 8 months four additional culms were removed from each box and these have been exposed for over 2 months without becoming infested. A third set of four culms from each box was removed at 10 months and no infestation has occurred. Spot iodine tests have indicated little if any starch present in the culms at the time they were removed from the boxes. No infestation of the culms stored in the boxes 6 months or longer followed by exposure up to 4 months has occurred. Again, spot iodine tests have indicated little if any starch in the culms at the time they were removed from the boxes. No infestation has occurred in the culms stored in the boxes 6 months or longer followed by exposure up to 4 months. It is not likely that later infestation will occur. These results indicate the practical possibility of storing cured culms under insectproof conditions for a few months in order to prevent later infestation.

VANILLA CULTURE AND PROCESSING

AGRONOMIC STUDIES

By Hector R. Cíbes and Norman F. Childers

Vanilla grown in one-half sunlight and Toa mulch gave highest yields for first crop.—An experiment has been under way since 1944 to determine the relative value of growing vanilla (*Vanilla fragrans* (Salisb.) Ames) under a lath shade of bamboo admitting one-half and one-third sunlight with three types of mulch with and without limestone (*15, pp. 44–46*). The mulches are being obtained from three different soil series, namely Catalina clay, Toa silty clay loam, and Soller clay. The vanilla began to flower early in 1947, during and after an extended dry period. The following October, 3 years and 8 months after the experiment was started, the number of beans per plot and the general condition of the vines were recorded.

It is obviously too early at this time to draw definite conclusions on the effect of different mulches and light treatments on the yield of vanilla. Results for the first fruiting year, however, give several interesting indications. In table 16 it is evident that there was greater production of beans under one-half sunlight than under one-third. Other observations indicate, in fact, that one-half sunlight may be inadequate for best fruiting of vanilla at Mayaguez. For example, while recording the data it was noted that the plots on the extreme east side of the lath house, where light is better, were all carrying heavy crops of beans (see table 16). This is due to the fact that under Mayaguez conditions sunlight is nearly always more abundant from sunrise to shortly after noon than from shortly after noon to sunset. Rains frequently occur in the afternoons, particularly during the summer season, while in winter clouds usually appear in late morning and the sky may be at least partly overcast for a large percentage of the afternoons. In this same connection it was of

further interest to note that the south ends of the beds usually bore more beans than the north ends; in this experiment all beds run from about northeast to southwest. Here again this may be due to the cross aisles, which run at right angles to the beds, admitting more light to the south ends of the beds, particularly during the midday high-light periods.

TABLE 16.—*The effect of amount of sunlight and source of mulch with and without limestone on the number of first-crop vanilla beans produced under lath shade at Mayaguez*

Replications	½ sunlight						¼ sunlight					
	Catalina	Catalina+ lime	Toa	Toa+ lime	Soller	Soller+ lime	Catalina	Catalina+ lime	Toa	Toa+ lime	Soller	Soller+ lime
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
1	75	6	101	91	156	0	71	0	57	188	3	60
2	31	94	[1] 132	72	2	0	0	0	66	[2] 616	5	1
3	99	32	148	278	207	0	7	0	286	6	37	0
4	[2] 266	10	100	224	319	133	23	0	224	38	153	46
5	[1] 64	[1] 0	[1] 267	67	206	132	51	12	297	72	47	0
6	0	0	[1] 156	248	107	22	[2] 274	0	168	272	136	1
7	18	[1] 165	[1] 123	94	114	110	45	[1] 227	130	[1] 330	20	14
8	154	[1] 374	285	233	310	284	181	172	65	2	123	24
Total	667	681	1,312	1,307	1,421	681	652	411	1,293	1,524	524	176
Grand Total	6,069						4,580					

[1] Indicates the beds showing severe wilting or death of vanilla vines.
[2] These beds were located on the east end of the lath-shade house and probably received more sunlight than those in other sections of the house.

The data in table 16, although somewhat variable, show that vanilla growing in Toa mulch both with and without limestone consistently produced high yields of beans in the first crop. Vanilla growing in Catalina clay with or without limestone consistently yielded a low average number of beans. It should be noted, however, that the two extreme east beds of vanilla in Catalina mulch produced 600 of the total 1,319 beans from all 16 beds of Catalina mulch. Vanilla vines in both of these high-yielding beds were in good condition.

Beds of vanilla which showed severe wilting or death of vines, possibly caused by the vanilla root rot fungus, *Fusarium batatatis* var. *vanillae* Tucker (*60, pp. 1121–1136*), are also shown in table 16. Beds receiving Soller mulch showed no pronounced symptoms of the disease, whereas five beds receiving Toa mulch and four beds receiving Catalina mulch all showed severe wilting or drying. It should be pointed out that most of the vines in poor condition were located in one section of the experiment where water stands in the aisles over a longer period after heavy rains, indicating slow drainage.

As yet, there seems to be no definite correlation between the addition of limestone to the mulch and the amount of wilting and dying of vines, nor does there appear to be a correlation between the addition of limestone to the mulch and yield. Source of the mulch and light intensity were apparently the most important factors affecting yield of the first crop of beans. Size of the beans grown under lath shade were in general much larger than those found under average commercial field conditions in Puerto Rico.

On the basis of these preliminary results it may be desirable to construct commercial lath houses in the future so as to admit somewhat more light than the maximum light admitted in this experiment. Another approach to this problem might be to remove a portion of the lath, perhaps every third slat, during the summer season when total sunlight is lower and humidity higher. In addition, it might be desirable to lay the lath and locate the beds in an east-west direction to allow for presumably more uniform light penetration and utilization. Under the present lath-house conditions mildew damage (*Phytophthora* sp.) has been observed on several of the beans and vines. This disease is definitely aggravated by high humidity and poor air circulation during the rainy season.

Vanilla root growth was best in Soller mulch.—The effect on vanilla root development of the above treatments in the lath shade experiment was measured by growing vanilla in V-shaped glass-sided boxes with removable wooden shades. Catalina clay to a depth of 4 inches was placed in the bottom of each box and above it were spread 3 inches of medium-size gravel and 10 inches of mulch alone or mixed with limestone. A group of six boxes each representing one of the six treatments was placed under one-half sunlight and another group was placed under one-third sunlight. Measurements of the rate of root elongation were taken daily after the roots appeared against the glass sides. A gummed label was used to mark the point where the roots first appeared; this also served to number each root for later reference and measurements. The main roots usually branched into numerous secondary roots. Growth of a given root was rapid for some time after it first appeared, then gradually decreased until elongation practically stopped.

The data showed that the best root growth during the first year was obtained from vines growing in Soller mulch, which agree with data reported elsewhere (*16, pp. 291–299*). Root development was slightly better when limestone was mixed with the Soller mulch. Root growth in Catalina mulch was the poorest, while that in Toa mulch with or without limestone was somewhat better than that obtained in Catalina mulch. In almost every case better root growth was obtained with plants under one-half sunlight than with those under one-third.

Light treatments had no effect on moisture content of mulch.—Samples of mulch and soil were taken from several plots in each treatment of the mulch-light experiment reported above to determine the influence of one-half and one-third sunlight on moisture content of the mulches, and the moisture of the soil underlying the mulches. The data showed that light intensity had no marked influence on the moisture content of the mulches. The soil moisture, however, was slightly higher under one-third than under one-half light.

Cooperative vanilla shade-house experiment established at Maricao.—The good growth and fruiting of vanilla under lath shade as described in the above lath-shade experiment formed the basis of a cooperative experiment established in June 1947 between the Federal station and the Mayaguez Tropical Products Co. located near Maricao, P. R. The experiment involved a comparison of three treatments each covering about one-half acre as follows: (1) Vanilla grown on a 45-percent slope on terraces 4 to 5 feet wide and about 200 feet long. Shade is provided by old-established coffee shade trees of pomarosa (*Caryophyllus jambos* (L. Stokes)) thinned to admit about 50 percent

sunlight; (2) vanilla grown on a 30-percent slope in continuous beds located on terraces 4 to 6 feet wide (bamboo lath spaced to admit about 50 percent sunlight); and (3) vanilla grown on a 30-percent slope on individual terraces each about 3 feet across, 8 by 10 feet apart, with rows arranged on the contour; shade is provided as in (1).

Irrigation is available for all plantings when needed by pumping water from a nearby stream through a system of pipes and garden hose. Vanilla plants in treatments 1 and 2 on continuous terraces are planted 5 feet apart using 5-foot stakes of living dwarf bucare as supports. Mulch is maintained at 8 to 12 inches deep in the beds and is obtained from a 1-acre plot of fertilized elephant grass. Mulch for treatment 3 comes from a prepared compost consisting of alternate layers of soil, fertilizer, and leafmold (*24*). The mulch beds immediately beneath the vanilla plants are underlain with 4 inches of creek gravel for drainage. Data for each treatment are taken from a group of 200 plants, laid out in a rectangle with the long axis up and down the slope.

Costs of labor and materials used in construction of the ½-acre area of each treatment are shown in table 17. All planting materials and tools were on hand except those used in constructing the irrigation system; these same tools were also used in erecting the lath-shade skeleton structure. Total cost of installing the centrifugal pump irrigation system was $475.21, broken down as follows: Pump—$349.46, tools—$39.55, and labor—$86.20.

Net returns per treatment will be determined over a 5- to 10-year or longer period, depending upon how long the vanilla is productive. This experiment should give Puerto Rican vanilla growers valuable information on yields under three distinct methods of growing vanilla and the net returns of each.

TABLE 17.—*Comparative costs of establishing three different treatments for growing vanilla* [1]

Treatment	Labor	Materials	Total
	Dollars	*Dollars*	*Dollars*
Live shade, continuous terraces	263.38		263.38
Lath shade, continuous terraces	745.03	701.28	1,446.31
Live shade, individual terraces	145.58		145.58

[1] Partial clearing of the areas netted some returns from charcoal.

Vanilla flowers set fruit when treated with growth-promoting substances.—Vanilla flowers, although hermaphroditic, must be hand-pollinated under commercial conditions. This operation involves considerable labor, time, and skill. Following the suggestion of P. W. Zimmerman, Boyce Thompson Institute for Research, and W. C. Cooper, Office of Foreign Agricultural Relations, various growth substances in different concentrations were tried. It was found that about 75 percent of all flowers fruited when sprayed with a solution containing 50 mg. of 2,4–D per liter (*23, pp. 33–34*). The highest set of fruit, 51 percent, was obtained by spraying unprotected buds in complete clusters with 90 mg. per liter of 2,4–D. The seedless beans which developed in this experiment were harvested and cured according to usual methods. The beans were straw-colored, brittle, had no aroma,

and in general did not compare favorably with hand-pollinated beans. The cured product was poor which indicates that the seeds and placental tissues are of primary importance in the development of aroma and bouquet of cured vanilla beans.

Hybrid vanilla seedlings received from Cornell.—In January 1947 about 40 hybrid vanilla seedlings growing in agar in test tubes were received from Dr. Lewis Knudson, Cornell University. The seedlings were from crosses made between *Vanilla fragrans* and *V. phaeantha* Reich. f. in Puerto Rico; seed were sent to Dr. Knudson who germinated and grew them by a special technique developed by him. *V. fragrans* is the widely grown high-quality commercial species which is highly susceptible to the vanila root-rot disease, *Fusarium batatatis* var. *vanillae*; *V. phaeantha* has a low-quality bean but is relatively resistant to the root disease as well as to adverse conditions of drought, excessive sun, and low soil fertility. The seedlings were transferred from the agar to 3-inch pots containing peat moss and expanded mica. They are being supplied with a full nutrient solution until ready for transplanting to the field.

VANILLA CURING

By Carlos F. Cernuda and Arnaud J. Loustalot

Infrared heat was tried in different stages of vanilla curing.—The application of heat, irrespective of light, is considered necessary for promoting and inducing the desired reactions during the various stages of curing vanilla beans. In commercial practice, the sun is usually the source of heat, but in some experiments performed at this station electric ovens have been used (*5*). In both cases a good product has been obtained, but the oven-cured beans were considered to be superior to those cured in the sun and the curing time was shorter.

The object of this experiment was to determine the practicability of using infrared lamps as a source of heat in one or more of the stages of vanilla curing.

Uniform and representative samples of green beans were divided into eight lots and subjected to the following curing treatments:

Killing	*Sweating*	*Drying*	*Conditioning*
Infrared	Infrared	Room temperature	Room temperature
Infrared	Infrared	Infrared	Room temperature
Infrared	Oven	Infrared	Room temperature
Infrared	Oven	Room temperature	Room temperature
Hot water	Infrared	Infrared	Room temperature
Hot water	Infrared	Room temperature	Room temperature
Hot water	Oven	Infrared	Room temperature
Hot water	Oven	Room temperature	Room temperature (check)

These eight treatments represented all possible combinations of the standard and infrared methods in the killing, sweating, and drying stages of vanilla curing. The standard method of conditioning at room temperature was the same for all treatments. Killing with hot water and oven-sweating was used as the control treatment.

Killing with infrared was conducted with the lamps adjusted at such a height that the temperature of the beans was 60° C., and beans were left under the lamps until browning occurred. Where the beans were killed with hot water, they were submerged three times for 10 sec-

onds in water at 80°, at an interval of 30 seconds between each immersion. Sweating was done both in the oven and with the lamps at a temperature of 45° until the beans were flexible. Beans were dried at a temperature of 35° under infrared lamps and at room temperature to one-third of their original fresh weight. The beans were conditioned for 4 months in closed boxes at room temperature until full aroma developed.

The infrared lamps were mounted in six tandems, each consisting of 3 lamps, which were so arranged that the number and height of the lamps could be adjusted to obtain the desired temperatures. Since the lamps were not enclosed, there was considerable loss of infrared energy under the conditions of this experiment. The results that would be obtained by using a closed infrared oven might vary appreciably from those obtained here.

Killing with infrared lamps was not satisfactory.—Beans killed with infrared heat at 60° C. turned brown after 6 to 8 hours of exposure, and when these were sweated under the lamps at 45°, they appeared dry, and had a strawy, hard, fibrous texture. They acquired either a yellowish or greenish-brown color, and a slightly sweet but undetermined aroma. Those killed the same way but oven-sweated became slightly flexible after 20 hours. These were less hard and less fibrous, and were more uniformly dehydrated. They attained a pale-brown color and developed a sweet aroma.

In general, the appearance of beans killed with infrared lamps at the end of the conditioning period was, without doubt, commercially unacceptable. These beans developed mold during conditioning, something that usually occurs when the killing treatment is ineffective. The relatively more intense heating during killing destroyed to some extent the protective waxy covering in the beans, thus rendering conditions favorable for rapid dehydration and the development of mold.

On the other hand, beans killed in hot water acquired a desirable flexibility when sweated. Sweating of these beans with infrared heat required an average of 2 days, after which they became oily and bright brown, while those sweated in the oven were flexible at the end of 5½ days.

Beans killed in hot water and sweated with infrared lamps gave a superior final product.—Probably because of the uniform application of heat in the hot-water method of killing, whereby all parts of the pods are exposed simultaneously, these beans, when sweated under the lamps at the relatively low temperature of 45° C., acquired a desirable flexibility and dark-brown color. Among all the treatments these beans had the best vanilla aroma and were superior in appearance at the end of the conditioning period.

Use of infrared at drying stage was of no advantage.—There was no marked difference in the aromatic quality of cured beans dried by different methods. Drying is a process that takes place as soon as the vanilla beans are subjected to heat. Although it is difficult to establish the exact time required for the individual stages—as the completion of each one has no true line of demarcation, it can be said that drying with infrared heat required from 1 to 5 hours. In some treatments the desired reduction in weight was attained at the end of the sweating period. Drying at room temperature required from 1 to 3 days. The drying phase consists mainly of dehydrating the

beans to a desired moisture content so that favorable conditions for mold development will not prevail. The manner in which this loss of moisture takes place is a physical process. The low temperature at which it was carried out in these experiments affected the quality and appearance of the beans similarly, though infrared drying was quicker than oven drying. Thus, infrared drying, other than speeding up the process, had no apparent effect on the aromatic quality of the cured beans.

Below are listed the effects of the eight curing treatments on the aroma and appearance of the vanilla beans:

Best—hot-water killed, infrared-sweated, infrared-dried beans.
Hot-water killed, infrared-sweated, room-temperature dried beans.

Good—hot-water killed, oven-sweated, infrared-dried beans.
Hot-water killed, oven-sweated, room-temperature dried beans.

Poor—infrared-killed, oven-sweated, room-temperature dried beans.

Very poor—infrared-killed, oven-sweated, infrared-dried beans.
Infrared-killed, infrared-sweated, infrared-dried beans.
Infrared-killed, infrared-sweated, room-temperature dried beans.

SPICE-PLANT INVESTIGATIONS

AGRONOMIC STUDIES

By Pedro Seguinot Robles, Carlos F. Cernuda, and Arnaud J. Loustalot

Ginger distributed for planting purposes.—There has been increased interest in the cultivation of Chinese ginger (*Zingiber officinale* Rosc.) and planting stock of this variety has been made available to interested farmers. During the last quarter of the year over 2 tons of planting stock were distributed in 100-pound lots. An additional 1½ tons were used in cooperative experiments with farmers at Barranquitas and Corozal.

Storage of planting stock of ginger under coarse river sand reduced losses from rot.—Planting stock of ginger must be properly stored to induce uniform sprouting of the buds or "eyes," as they are generally called. In past years storage at the station had been done by spreading the "hands" out in consecutive layers using dry sea sand as a medium. The hands were frequently turned to detect rotting and reduce storage heat. Even with such precautions a high percentage of loss was always observed, varying from 10 to 25 percent by weight. During early 1947 nearly 6 tons of Chinese ginger rhizomes were harvested from experimental plots and stock plantings. In storing this planting stock, coarse river sand was used as a good medium for storing ginger planting stock, as the incidence of storage rot was less than 0.5 percent. Only 45 pounds out of 11,756 pounds of ginger rhizomes stored were lost this year because of rot.

Composted manures resulted in significant increases in yields of fresh ginger.—In June 1946, an experiment was initiated to determine the effects of seven manurial treatments on the yields of Chinese ginger. The treatments were as follows: (1) Compost, consisting of 2 tons per acre barnyard manure, 2 tons per acre leafmold, and 300

pounds fertilizer 6–9–10; (2) 15 tons per acre barnyard manure; (3) 5 tons per acre leafmold and 600 pounds per acre fertilizer 6–9–10; (4) 5 tons per acre barnyard manure and 600 pounds per acre fertilizer 6–9–10; (5) 15 tons leafmold; (6) fertilizer 900 pounds per acre, 450 pounds per acre at planting time, and 450 pounds per acre 3 months after planting; and (7) control, no treatment. After 8 weeks the germination was estimated at 90 percent. The attacks of two insects, *Alasmopolpus lignocellus* Zeller and *Scapteriscus vicinus* Scudder, accompanied by low rainfall conditions were factors contributing to a somewhat reduced stand. Nutgrass, *Cyperus rotundus*, and "cohitre," *Commelina elegans*, were the most persistent weeds.

No symptoms of nutrient deficiencies occurred except in the leafmold plots where nitrogen deficiency was apparent. Except for the check plots, yield of ginger was lowest in the leafmold plots.

The plots were harvested during January 1947 after a 7-month growing season and analyzed for variance. The yield differences showed that treatments (1) to (4) inclusive gave a significantly higher yield than the control. These results indicate that composts made from farm residues and augments with commercial fertilizers increase yields of green ginger.

Higher yields of fresh and dry ginger produced under shade.—The first harvest in an experiment, in which Chinese ginger was grown for candying, was made in September 1946. The ginger was grown under sun and partial shade, and harvested at four different stages of maturity. In 8 plots, each 240 square feet, 120 seed pieces of ginger were planted. Four of the plots were under sun and four were under partial shade (two-thirds). The plots were harvested at monthly intervals beginning 4 months after planting; thus the ginger of the last harvest was 7 months old. Yield records and samples for moisture and fiber determinations were taken from sun and shade plots at each harvest date. The rest of the ginger was used for a candying experiment.

The sun and shade treatments did not have any noticeable effect on the appearance, shape, or size of the green ginger hands. However, the ginger harvested at 4 months had a thinner and softer outer skin and appeared to be more tender than that harvested later.

The data presented in table 18 show that with the exception of the first harvest, the yield of green ginger was higher when grown in the shade than when grown in the sun. The percentage of dry matter in ginger grown under both sun and shade increased with each successive harvest. Contrary to expectations, the moisture content of the ginger grown under sun was higher than that of the ginger grown in the shade, particularly at the last harvest. Thus, the yield of dry ginger per acre was considerably greater under shade than under sun. Plants grown in the shade are usually more succulent and have a higher moisture content than those grown in the sun. In this experiment the reverse was true. Apparently the synthesis of dry matter proceeded at a faster rate under shade than in the sun. The fact that leaves of ginger plants grown in the sun were small and chlorotic indicates that the sun had a deleterious effect on the plant and probably reduced the rate of photosynthesis or increased the rate of respiration, or both. Since soil moisture, in either sun or shade plots, was never a limiting factor, the plants were always turgid.

TABLE 18.—*Yield, dry matter, moisture, and crude fiber content of ginger grown under sun and shade, and harvested at four stages of maturity*

Time of harvest	Dry matter		Moisture		Yield of fresh ginger per acre		Crude fiber (oven-dry basis)	
	Sun	Shade	Sun	Shade	Sun	Shade	Sun	Shade
Months after planting	*Percent*	*Percent*	*Percent*	*Percent*	*Pounds*	*Pounds*	*Percent*	*Percent*
4	4.40	4.35	95.60	95.65	4,180	4,000	11.72	12.47
5	5.67	7.58	94.33	92.42	5,090	7,640	12.72	12.20
6	8.66	9.05	91.34	90.95	5,820	8,010	7.18	7.88
7	14.19	18.98	85.81	81.02	6,550	8,010	5.77	6.03

The analysis for crude fiber, also presented in table 18, shows that this constituent decreased from about 12 percent at the first harvest to about 6 percent at the last harvest. The fiber content from sun and shade plots was not markedly different, although ginger from the shade plots had slightly but not significantly more fiber than that from the sun plots.

The results of this experiment indicate that ginger should be grown under partial shade to obtain the best yields of either fresh or dry ginger. The yield of ginger 7 months after planting was double that harvested 4 months after planting.

PROCESSING STUDIES

By CARLOS F. CERNUDA and ARNAUD J. LOUSTALOT

Ginger harvested after 6 months gave best candied product.—At each of the four harvest dates referred to in the previous section, the ginger rhizomes grown under sun and under shade were partially peeled, washed, and immersed for 4 weeks in brine containing ½ pound of salt to 1 gallon of water During this "pickling" time the ginger lost some of its biting quality, the epidermis was softened, and some translucency occurred in the tissues. The salted rhizomes were then boiled in fresh water and washed in a continuous flow of water to remove the salt. The remaining outer skin was easily removed at this time. The ginger hands were then immersed in a sugar sirup of 22° Baumé, and every 3 days the density was increased 3 degrees by further addition of sugar until 35° Baumé was reached.

Final glacéing was accomplished by immersing the ginger in a thoroughly agitated sugar sirup of 36° Baumé. The rhizomes dried rapidly when removed from the mother liquor. They were then wrapped in waxed paper and stored in tin friction-top containers until all were processed and ready for testing. Representative samples with coded number from each treatment were sent to various qualified individuals for organoleptic testing. The candied ginger was judged on its appearance and biting and fibrous quality.

The samples judged as having the best all-round quality and appearance were those harvested at 6 months and grown either in sun or shade. The second best were those harvested after 5 months. The samples from the other treatments were generally judged poor in quality and appearance.

The results of this experiment indicate that the best yields of ginger for candying purposes were obtained after the rhizomes had been in

the field for 6 months. Ginger harvested after 7 months gave higher yields but the quality of the candied product was inferior to that harvested a month earlier. The ginger harvested at 4 months not only yielded less but produced a poor quality product.

COFFEE VARIETY STUDIES

By Luis A. Gomez and Jose Leria Esmoris [26]

Columnaris coffee continued to outyield the Puerto Rico variety.—The Columnaris variety of *Coffea arabica* L., from Java, introduced by the station several years ago continued to outyield the West Indian variety for the crop year 1946. Corresponding yields for both varieties in pounds of marketable coffee per acre were: Columnaris 1,337 pounds and West Indian 481. A reduction in yield of the West Indian variety occurred in 1946 in contrast to a definite increase in the yield of Columnaris. The average per acre yields for the past 13 harvests were Columnaris 1,074 pounds and West Indian 619.

SOIL CONSERVATION PRACTICES

OBSERVATIONAL INVESTIGATIONS [27]

By Emery A. Telford [28] and Fernando Abruna [29]

Velvetbeans fertilized with lime and phosphorus increased subsequent yields of sweetpotatoes and corn.—An experiment was started in May 1944 to determine the effect of fertilized leguminous cover crops on yields of sweetpotatoes and corn. The legumes used were (1) velvetbeans (*Stizolobium deeringianum* Bort.), (2) crotalaria (*Crotalaria mucronata* Desv.), (3) Venezuelan cowpeas (*Vigna sinensis* (Torner) Hassk.), and (4) soybeans (*Glycine max* (L.) Merr. var. Ottotan). The varieties of sweetpotatoes and corn consisted of Don Juan and Mayorbela, respectively.

The plots were one-hundredth acre in size and laid out on the contour between terraces in a randomized-block design. There were 10 treatments each replicated 9 times in each of 2 fields, A and B, located on Catalina clay having an average pH from 4.5 to 5.0. On field A the green manure from the cover crop was cut, weighed, and left on the surface to decompose. After 2 or 3 weeks the residue was easily worked into the soil by hand. In field B the green manure was cut, weighed, and incorporated immediately into the soil by tractor-drawn equipment. The fertilized plots received lime ($Ca(OH)_2$) at the rate of 4 tons per acre and superphosphate (P_2O_5) at 100 pounds per acre. These materials were applied only the first year and were worked into the soil about 2 weeks before the first legume crops were planted. During the first year, sweetpotatoes were planted imme-

[26] Members of the staff of the Agricultural Experiment Station of the University of Puerto Rico.

[27] A progress report on the cooperative (Purnell) Project (No. 16) between the Soil Conservation Service, the Puerto Rico Agricultural Experiment Station at Rio Piedras, and the Federal Experiment Station at Mayaguez.

[28] Associate conservationist, United States Department of Agriculture, Soil Conservation Service.

[29] Research assistant in soil conservation, Agricultural Experiment Station, University of Puerto Rico.

diately after the incorporation of the leguminous cover crops. In the second year the same cover crops were replanted and then followed by corn. All plantings were made in accordance with standard procedure for the respective crops. The treatments and yields of green manure, sweetpotatoes, and corn over a 2-year period are given in table 19.

TABLE 19.—*Average yields per acre of green manure, sweetpotatoes, and corn from fertilized and unfertilized cover-crop plots*

Treatments	Yield per acre			
	Green manure from 2 crops 5/44, 11/44	Sweetpotatoes 4/45, 9/45	Green manure from 2 crops 10/45, 6/46	Corn 8/46, 12/46
	Cwt.	*Cwt.*	*Cwt.*	*Cwt.*
Check	Fallow from 5/44 to 3/45	47.08	Fallow	1.58
Check, lime and P_2O_5	do	56.94	do	6.11
Velvetbeans	157.80	44.43	156.68	6.22
Velvetbeans, lime and P_2O_5	225.20	71.34	203.17	13.27
Crotalaria	29.10	49.47	48.53	2.33
Crotalaria, lime and P_2O_5	31.20	55.12	75.33	8.05
Cowpeas	142.40	37.55	30.37	3.42
Cowpeas, lime and P_2O_5	161.40	64.36	32.52	8.19
Soybeans	65.60	25.39	29.80	2.47
Soybeans, lime and P_2O_5	123.60	57.46	50.10	7.72

Of the leguminous cover crops tested, velvetbeans was the best as measured by the yield of green manure produced per acre, and by its beneficial effect on subsequent yields of sweetpotatoes and corn. The addition of lime and phosphate to the legumes increased the yield of green manure in all cases, but it was particularly beneficial in the case of velvetbeans and soybeans. The sweetpotato yield following two successive crops of velvetbeans was significantly higher than that obtained following other legumes. The yield of sweetpotatoes was depressed by cowpeas and soybeans. Addition of lime and phosphate either alone or in combination with legumes increased the yield of sweetpotatoes.

The effect of the fertilized and unfertilized cover crop treatments on the yields of corn was essentially in the same order as that of the first year with sweetpotatoes. Although no lime and phosphate were applied the second year, the beneficial residual effects of these materials on increased yields were apparent. The application of lime and phosphate without legume rotation increased corn yields from 1.58 cwt. to 6.11 cwt. per acre. When velvetbeans, fertilized with lime and phosphate, were grown previous to planting the corn, the yield of corn averaged 13.27 cwt. per acre.

The cost of producing an acre of velvetbeans properly fertilized with lime and phosphate should not exceed $35. The total cost would be less if a commercial nitrogen application were substituted for the legume crop in the rotation. However, this would not supply organic matter which is valuable in reducing soil erosion. In the course of the foregoing experiment it was observed that soil erosion was greatly reduced on the fertilized legume plots and partially checked on the unfertilized legume plots, whereas many small gullies were formed on all fallow check plots. Plots fertilized with mineral fertilizer only

would probably erode like these check plots. A crop of velvetbeans can be grown during the season of the year when cash crops are not usually grown.

The per acre value of the sweetpotatoes grown on the check plots was $141.24 while on the fertilized velvetbean plots the value per acre amounted to $214.02. The value per acre of the corn on the check plots was $7.90 against $76.35 from the treated plots. Under the conditions of these experiments no significant difference in sweetpotato and corn yields was found when the green manure crop was used as mulch, as in field A, or incorporated into the soil immediately, as in field B.

The results of this experiment demonstrate that unproductive acid clay soils in Puerto Rico can be economically improved by the application of lime, superphosphate, and the use of a vigorous-growing legume such as velvetbeans.

Sugarcane trash on hillsides reduced soil erosion.—At the Federal station in Puerto Rico there are 12 runoff plots each $\frac{1}{10}$ acre in size, on Catalina clay soil having an average slope of 40 percent. These are grouped into 6 randomized blocks of 2 plots each. Before planting, all plots were covered with dry sugarcane trash at the rate of 5 tons per acre. The trash was burned on one plot of each block and on the other it was raked into rows across the plot and left as mulch. The cane was planted in holes 18″×24″×6″ with a vertical and horizontal distance between holes of 2½ by 2 feet, respectively. In the corners of each hole a cutting of sugarcane variety POJ–2878 was planted in April 1944. Two applications of complete fertilizer (14–6–8) at the rate of 600 pounds per acre were made to all plots each year. The first year the initial application was made at the time of planting and the second was made approximately 60 days later. In subsequent years one-half the fertilizer was applied to the ratoons after harvesting and the remainder about 60 days later. Replanting, weeding, and cultivating have been maintained in a similar manner on all plots for the 3 years the experiment has run. The trash is burned on one set of six plots following each harvest and left as mulch on the other six plots. The cane trash mulch left on the surface of the soil decomposes in 4 to 6 months, but the growth of new cane is sufficient to protect the soil at this time. The soil losses and cane yields for the "primavera" and two ratoon crops are given in table 20.

The soil losses from the mulched plots are considerably less than from the unmulched plots, the differences being highly significant.

TABLE 20.—*A comparison of soil losses and sugarcane yields under different treatments*

Year	Rainfall	Treatment 1 [1]		Treatment 2 [2]	
		Soil loss	Marketable cane yield	Soil loss	Marketable cane yield
	Inches	*Tons/acre*	*Tons/acre*	*Tons/acre*	*Tons/acre*
1944–45	68.06	0.79	24.60	9.88	24.97
1945–46	91.71	1.22	28.55	16.17	31.81
1946–47	66.57	.46	31.89	3.11	31.82

[1] All cane trash used as mulch. Surface soil never exposed.
[2] All cane trash burned on surface of plots. Surface soil exposed to heavy rains from 2 to 4 months each year.

The cane yields to date show no significant difference between the mulched and burned treatments. The deleterious effects of soil erosion on the burned plots may not be apparent because of the heavy applications of mineral fertilizers each year. The 1947–48 crop is being grown with only one application of 600 pounds of fertilizer per acre. At the present time the cane on the mulched plots appears to be making significantly better growth than that on the unmulched plots. The yield data of these plots will be obtained in February 1948.

Weeding costs of the mulched plots average about one-third less than that of the burned plots. The practice of mulching sugarcane, as in these experiments, is recommended because it reduces weeding, helps to prevent erosion, and eventually should increase yields.

WEATHER CONDITIONS

By William Vargas

Rainfall below average for fiscal year 1946–47.—Total rainfall for the last 6 months of 1946 was 50.24 inches, or 3.89 inches below the 48-year average, and for the first 6 months of 1947, 22.68 inches, or 7.41 inches below the 49-year average. May, September, and November had above-average precipitation but during the remainder of the year rainfall was below normal, especially between December and April.

The mean temperature record at Mayaguez for the fiscal year 1946–47 was 77.7° F., 0.4° higher than the 48-year average of 77.3°. The complete weather details are given in table 21.

Table 21.—*Weather conditions at the Federal Experiment Station, Mayaguez, P. R., during the fiscal year 1946–47*

Month	Precipitation			Character of day			Temperature [2]				
	Total [1]	Greatest in 24 hours	Days with 0.01 inch or more	Clear	Partly cloudy	Cloudy	Mean maximum	Mean minimum	Mean	Maximum	Minimum
1946	*Inches*	*Inches*	*Number*	*Number*	*Number*	*Number*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*
July	6.36	1.62	11	11	11	9	89.8	68.7	79.3	95	67
August	9.48	1.45	19	13	16	2	90.9	69.0	80.0	95	66
September	11.75	1.74	24	6	15	9	90.4	68.3	79.4	93	66
October	8.93	1.60	19	7	12	12	88.3	69.6	79.0	93	68
November	7.99	1.71	12	10	10	10	86.4	68.0	77.2	91	66
December	1.82	.75	12	18	8	5	86.6	65.7	76.7	90	60
1947											
January	1.14	.23	10	12	11	8	85.5	63.9	74.7	89	61
February	1.35	.37	7	10	5	[3] 5	87.4	64.6	76.0	93	59
March	.24	.09	6	11	15	5	89.3	64.2	76.8	93	62
April	3.97	1.32	16	7	12	11	87.6	64.4	76.0	92	62
May	8.37	1.55	21	7	9	15	89.0	66.5	77.8	93	65
June	7.61	1.84	12	6	10	[3] 8	90.4	67.8	79.1	94	65

[1] 48-year average: July, 10.50 in.; August, 11.14 in.; September, 10.88 in; October, 9.31 in.; November 5.86 in.; and December, 2.55 in.

49-year average: January, 2.04 in.; February, 2.02 in.; March, 3.73 in.; April, 5.09 in.; May, 8.36 in.; and June, 8.85 in.

[2] 47-year Mean temperature: July, 79.0°; August, 79.3°; September, 79.4°; October, 79.1°; November, 77.6°; and December, 76.0°.

48-year Mean temperature: January, 74.7°; February, 74.8°; March, 74.9°; April, 76.1°; May, 77.8°; and June, 78.7°.

[3] No observations were made as to character of day by substitute observer from February 3 to February 10, inclusive, and from June 16 to June 21, inclusive.

PHYSICAL-PLANT IMPROVEMENTS

The sum of $56,000 was appropriated by Congress for the construction of seven new staff houses during the fiscal year. Because of increased costs of labor and materials, it was necessary to modify the original plans and build smaller houses than were contemplated. A contract for the construction of the houses was awarded to a local contractor, and at the close of the fiscal year the construction was well under way.

These seven new houses will permit the removal of some of the older wooden buildings which are badly termite-ridden and in poor condition. The new houses are being constructed of reinforced concrete and concrete blocks, and are designed to be earthquake- and hurricane-proof. The design used was prepared through the courtesy and cooperation of the Office of Foreign Agricultural Relations, which assigned one of its engineers, Mr. Vergil C. Pettit, to draw the plans and specifications.

Funds in the amount of $3,000 were also allotted to the station for the construction of a head house to the greenhouse units. This unit provides ample storage space for mixing soil and fertilizers, potting facilities, and other uses in connection with the plant introduction and plant physiological work being conducted at the station.

Congress also provided funds in the amount of $3,000 to provide a sewage system for the staff houses and other station facilities. This sewage system connects with the insular disposal system and does away with the use of septic tanks and other methods of sewage disposal. The installation of the sewage facilities was made in cooperation with the College of Agriculture of the University of Puerto Rico to the mutual advantage of both institutions. Through a memorandum of understanding, the college appropriated funds for enlarging the over-all size of the line and helping in the construction work; in return, the sewage facilities of the college are connected to the main disposal line.

There were the usual routine physical-plant improvements, such as painting the doors and windows of the main station building, major repairs to the director's house, and other repairs as necessary throughout the station.

PUBLICATIONS

DISTRIBUTION OF REPORTS

Increased demand for station publications continued and a noticeable increase in requests from Latin America was noted. During the year a record of the current work of the station was published, as customary, in quarterly mimeographed reports, totaling 173 pages, for interoffice circulation and for distribution on request to agencies and individuals particularly interested in the work under way.

PUBLICATIONS ISSUED

The following publications were issued during the year:

ARANA, FRANCISCA E. La curá de la vainilla. Puerto Rico (Mayaguez) Fed. Expt. Sta. Cir. 25, 22 pp., illus. 1946.

CHILDERS, NORMAN F., and WHITE, DAVID G. Manila grass for lawns. Puerto Rico (Mayaguez) Fed. Expt. Sta. Cir. 26, 16 pp., illus. 1947.

TELFORD, EMERY A., and CHILDERS, NORMAN F. Tropical kudzu in Puerto Rico. Puerto Rico (Mayaguez) Fed. Expt. Sta. Cir. 27, 30 pp., illus. 1947.

The following articles were published by the station staff in periodicals outside the Department:

BARTLETT, KENNETH A. Federal Experiment Station in Puerto Rico. Chemurg. Digest 6 (3): 61–63, illus. 1947.

CHILDERS, NORMAN F. An ideal tropical lawn grass. Agr. in Americas 6: 145–147, illus. 1946.

CHILDERS, NORMAN F. La perspectiva para productos especiales en Puerto Rico. Rev. de Agr. de Puerto Rico 37: 271–276. 1946.

CHILDERS, NORMAN F., and SEGUINOT ROBLES, PEDRO. Slobolt lettuce in the tropics. Agr. in Americas 7: 93–95, illus. 1947.

HUME, EDWARD P. Difficulties in mangosteen culture. Trop. Agr. [Trinidad] 24: 32–36. 1947.

HUME, EDWARD P., and COBIN, MILTON. Relation of seed size to germination and early growth of mangosteen. Amer. Soc. Hort. Sci. Proc. 48: 298–302, illus. 1946.

JONES, MERRIAM A. A confirmatory modification of the test for rotenone-type compounds. Assoc. Off. Agr. Chem. Jour. 29: 127–129. 1946.

JONES, MERRIAM A., WHITE, DAVID G., and PAGÁN, CALEB. Evaluation of some clones of *Derris elliptica*. Trop. Agr. [Trinidad] 23: 89–93, illus. 1946.

LOUSTALOT, ARNAUD J. A semi-quantitative quick test for determining quinine in cinchona bark. Amer. Soc. Hort. Sci. Proc. 48: 386–390. 1946.

LOUSTALOT, ARNAUD J., and PAGÁN, CALEB. A quick and simple method for the determination of quinine and total alkaloids in cinchona bark. Assoc. Off. Agr. Chem. Jour. 30: 153–159, illus. 1947.

MOORE, R. H. Some effects of altitude and water supply on the composition of *Derris elliptica*. Bot. Gaz. 107: 467–474, illus. 1946.

PLANK, HAROLD K. Grassworm injury to lawns in Puerto Rico. Trop. Agr. [Trinidad] 24: 7–8. 1947.

TELFORD, EMERY A., and CHILDERS, NORMAN F. Tropical kudzu. Better Crops With Plant Food 30 (8): 24–25, 44–46, illus. 1946.

WHITE, DAVID G. Longevity of bamboo seed under different storage conditions. Trop. Agr. [Trinidad] 24 (4–6): 51–53, illus. 1947.

WHITE, DAVID G., COBIN, MILTON, and SEGUINOT ROBLES, PEDRO. The relation between curing and durability of *Bambusa tuldoides*. [U. S. Dept. Agr., Forest Serv.] Carribean Forester 7: 253–273, illus. [Span. trans. pp. 267–273.] 1946.

WHITE, DAVID G., and VILLLAFAÑE, AIDA G. A tropical weed killer. Agr. in Americas 6: 126–128, illus. 1946.

WINTERS, HAROLD F., LOUSTALOT, ARNAUD J., and CHILDERS, NORMAN F. Influence of temperature on growth and alkaloid content of cinchona seedlings. Plant Physiol. 22: 42–50, illus. 1947.

LITERATURE CITED

(1) ANONYMOUS.
1946. COSTA RICA'S NEW INSECTICIDE. Chemurg. Digest 5 (20): 351.

(2) ———
1946. NUTRICULTURE. U. S. War Dept. Tech. Manual TM–20–500, 84 pp., illus. Washington, D. C.

(3) ———
1947. HYDROPONIC GARDENS SUPPLY ARMY STATIONS WITH FRESH VEGETABLES. Market Growers Journal 76 (9): 8, 21, 22.

(4) ———
1945. PENTACHLOROPHENOL, AN IDEAL WOOD PRESERVATIVE. Down to Earth 1 (2): 1–5, illus.

(5) ARANA, F. E.
1944. VANILLA CURING AND ITS CHEMISTRY. PUERTO RICO (MAYAGUEZ) FED. EXPT. STA. BUL. 42, 17 pp., illus.

(6) ASENJO, CONRADO F.
1946. A CHEMICAL STUDY OF THE "MOLINILLO" PLANT (LEONOTIS NEPETAEFOLIA L.), WITH SPECIAL REFERENCE TO ITS SEED. REV. DE AGR. DE PUERTO RICO 38: 24. (Paper read at annual meeting of the Puerto Rican chapter of the Amer. Soc. Agr. Sci., Mayaguez, Sept. 2, 1946.)

(7) BURNS, W.
1940. CINCHONA CULTIVATION IN THE NETHERLANDS INDIES. Indian Farming 1: 311–317.
(8) CARSWELL, T. S., and NASON, H. K.
1938. PROPERTIES AND USES OF PENTACHLOROPHENOL. Indus. and Engin. Chem. 30: 622–626, illus.
(9) CHILDERS, N. F.
1946. AN IDEAL TROPICAL LAWN GRASS. Agr. in Americas 6: 145–147, illus.
(10) ———, WINTERS, H. F., SEGUINOT ROBLES, P., and PLANK, H. K.
1946. FOOD-CROP INVESTIGATIONS: VEGETABLE INVESTIGATIONS. Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt. 1945: 31–33.
(11) ———, WINTERS, H. F., SEGUINOT ROBLES, P., and PLANK, H. K.
1947. FOOD-CROP INVESTIGATION: VEGETABLE INVESTIGATIONS. Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt. 1946: 23–27.
(12) ——— and WHITE, D. G.
1947. MANILA GRASS FOR LAWNS. Puerto Rico (Mayaguez) Fed. Expt. Sta. Cir. 26: 16 pp., illus.
(13) CHRISTIAN, M. B.
1940. CHEMICAL DIP TESTS AGAINST LYCTUS POWDER-POST BEETLES. South. Lumberman, December 15, 1939: 105–109.
(14) ———
1940. LYCTUS BEETLE DAMAGE PREVENTION. South. Lumberman, June 15, 1940: 47–49, illus.
(15) CÍBES, H. R.
1946. VANILLA: AGRONOMIC STUDIES. Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt. 1945: 44–47.
(16) ———, CHILDERS, N. F., and LOUSTALOT, A. J.
1947. INFLUENCE OF MINERAL DEFICIENCIES ON GROWTH AND COMPOSITION OF VANILLA VINES. Plant Physiol. 22: 291–299, illus.
(17) CLAUSEN, C. P.
1940. ENTOMOPHAGOUS INSECTS. 688 pp., illus. New York and London.
(18) COBIN, M.
1945. BAMBOO PRODUCTION AND UTILIZATION. Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt. 1944: 29–31.
(19) GERSDORFF, W. A.
1935. A NEW CRITERION FOR THE COMPARISON OF TOXICITY WITH RESPECT TO CONCENTRATION AND TIME. Jour. Agr. Res. 50: 881–891, illus.
(20) GUNTHER, F. A.
1945. QUANTITATIVE ESTIMATION OF DDT AND DDT SPRAY AND DUST DEPOSITS. Indus. & Engin. Chem., Analyt. Ed. 17 (3): 149.
(21) HAMBRIDGE, G., ED.
1941. HUNGER SIGNS IN CROPS. 327 pp., illus. Washington, D. C. (Amer. Soc. Agron. and Natl. Fert. Assoc.)
(22) HARPER, R. E., and WINTERS, H. F.
1946. DRUG-CROP INVESTIGATIONS: CINCHONA PROPAGATION. Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt. 1945: 25–28.
(23) HERNÁNDEZ MEDINA, E., and RIVERA PÉREZ, J.
1944. VANILLA: PRODUCTION STUDIES. Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt. 1943: 32–34.
(24) HOAGLAND, D. R., and ARNON, D. I.
1938. THE WATER-CULTURE METHOD FOR GROWING PLANTS WITHOUT SOIL. Calif. Agr. Expt. Sta. Cir. 347, 39 pp., illus.
(25) HOPKINS, W. C.
1946. FENCE POSTS: PRODUCTION AND TREATING COSTS. Miss. Agr. Expt. Sta. Bul. 439: 27 pp., illus.
(26) JONES, M. A.
1945. APPLICATION OF A MODIFIED RED-COLOR TEST FOR ROTENONE AND RELATED COMPOUNDS TO DERRIS AND LONCHOCARPUS. Assoc. Off. Agr. Chem. Jour. 28: 352–359, illus.
(27) ———
1946. A CONFIRMATORY MODIFICATION OF THE TEST FOR ROTENONE-TYPE COMPOUNDS. Assoc. Off. Agr. Chem. Jour. 29: 127–129.
(28) ———, and GERSDORF, W. A.
1945. INSECTICIDAL-CROP INVESTIGATIONS: RELATIVE TOXICITY OF ROTENONE PLANTS. Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt. 1944: 9–10.

(29) ———, Gersdorff, W. A., and McGovran, E. R.
1946. A TOXICOLOGICAL COMPARISON OF DERRIS AND LONCHOCARPUS. Jour. Econ. Ent. 39: 281–283.
(30) ———, Moore, R. H., and Cooper, W. C.
1945. INSECTICIDAL-CROP INVESTIGATIONS: DERRIS CUTTING EXPERIMENTS. Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt. 1944: 5–7.
(31) ———, Pagán, C., McGovran, E. R., Gersdorff, W. A., and Piquett, P. G.
1947. INSECTICIDAL-CROP INVESTIGATIONS: RELATIVE TOXICITY OF ROTENONE PLANTS. Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt. 1946: 7–8.
(32) ———, White, D. G., and Pagán, C.
1946. EVALUATION OF SOME CLONES OF DERRIS ELLIPTICA. Trop. Agr. [Trinidad] 23 (5): 89–93, illus.
(33) Kiplinger, D. C., and Laurie, A.
1942. GROWING ORNAMENTAL GREENHOUSE CROPS IN GRAVEL CULTURE. Ohio Agr. Expt. Sta. Bul. 634, 52 pp., illus.
(34) Laurie, A., and Kiplinger, D. C.
1944. CULTURE OF GREENHOUSE ROSES. Ohio Agr. Expt. Sta. Bul. 654: 94 pp., illus.
(35) Lee, A., Watson, A. N., and Gibbons, D. F.
1937. BAMBOO INTRODUCTION, PROPAGATION AND UTILIZATION. Puerto Rico (Mayaguez) Agr. Expt. Sta. Rpt. 1936: 27–39.
(36) Loustalot, A. J.
1946. A SEMI-QUANTITATIVE METHOD FOR ESTIMATING QUININE IN CINCHONA BARK. Amer. Soc. Hort. Sci. Proc. 48: 386–390.
(37) ———, and Pagán, C.
1947. A QUICK AND SIMPLE METHOD FOR THE DETERMINATION OF QUININE AND TOTAL ALKALOIDS IN CINCHONA BARK. Assoc. Off. Agr. Chem. Jour. 30: 153–159, illus.
(38) ——— and Pagán, C.
1947. DRUG-CROP INVESTIGATIONS: CHEMISTRY. Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt. 1946: 21–23.
(39) McGovran, E. R., and Piquett, P. G.
1946. TOXICITY TO MEXICAN BEAN BEETLE OF DERRIS AND LONCHOCARPUS SAMPLES FROM PUERTO RICO AND A COMPARISON WITH RESULTS ON HOUSEFLIES. U. S. Dept. Agr., Bur. Ent. and Plant Quar. Spec. Rpt. No. 33.: 10 pp. [Processed.]
(40) Molitor, C.
1947. WHAT THEY MEAN BY MAGIC. Amer. Home 38 (3): 64–67, illus.
(41) Moore, R. H.
1945. MINERAL DEFICIENCIES IN DERRIS ELLIPTICA. Puerto Rico (Mayaguez) Fed. Expt. Sta. Bul. 43, 26 pp., illus.
(42) ———
1945. INSECTICIDAL CROP INVESTIGATIONS: PROPAGATION AND DISTRIBUTION. Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt. 1944: 4–5.
(43) Pagán, C.
1948. THE USE OF "GUPPIES" (LEBISTES RETICULATUS) IN THE TOXICOLOGICAL ASSAY OF DERRIS AND LONCHOCARPUS ROOTS. Jour. Econ. Ent. [In press.]
(44) ———, and Loustalot, A. J.
1948. A SIMPLE RAPID METHOD FOR ESTIMATING TOXICITY (ROTENONE EQUIVALENT) OF DERRIS ROOT. Jour. Agr. Res. [In press.]
(45) ———, and Loustalot, A. J.
1948. A COMPARISON OF CHEMICAL CONSTITUENTS OF DERRIS AND LONCHOCARPUS ROOTS WITH THEIR TOXICOLOGICAL VALUE (ROTENONE EQUIVALENT). Trop. Agr. [Trinidad]. [In press.]
(46) ———, and White, D. G.
1948. THE EVALUATION OF ROTENONE IN DERRIS ELLIPTICA ON THE BASIS OF TOTAL CHLOROFORM EXTRACTIVES. Assoc. Off. Agr. Chem. Jour. [In press.]
(47) Plank, H. K.
1938. INVESTIGATIONS OF THE POWDER-POST BEETLE IN BAMBOO. Puerto Rico (Mayaguez) Agr. Expt. Sta. Rpt. 1938: 109–118, illus.
(48) ———
1943. ENTOMOLOGY: GENERAL INVESTIGATIONS. Puerto Rico (Mayaguez) Agr. Expt. Sta. Rpt. 1942: 12–15.

(49) PLANK, H. K.
1944. INSECTICIDAL PROPERTIES OF MAMEY AND OTHER PLANTS IN PUERTO RICO. Jour. Econ. Ent. 37: 737–739.
(50) ———
1946. INSECTICIDAL CROP INVESTIGATIONS: PLANT TOXICOLOGICAL STUDIES. Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt. 1945: 22–25.
(51) ———
1946. BAMBOO PRODUCTION AND INDUSTRIALIZATION: BAMBOO POWDER-POST BEETLE. Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt. 1945: 43.
(52) ———
1947. INSECTICIDAL-CROP INVESTIGATIONS: PLANT TOXICOLOGICAL STUDIES. Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt. 1946: 11–13.
(53) ———
1947. ENTOMOLOGY AND ECONOMIC ZOOLOGY: DDT INVESTIGATIONS. Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt. 1946: 32–33.
(54) ———
1947. DDT FOR POWDER-POST BEETLE CONTROL IN BAMBOO. Science 106 (2753): 317.
(55) ——— and SMITH, M. R.
1940. A SURVEY OF THE PINEAPPLE MEALYBUG IN PUERTO RICO AND PRELIMINARY STUDIES OF ITS CONTROL. Puerto Rico Univ. Jour. Agr. 24: 49–76.
(56) SLEESMAN, J. P., and GUI, H. L.
1945. EXPERIMENTS WITH DDT CONDUCTED BY STATE [OHIO] AGRICULTURAL EXPERIMENT STATIONS, AGRICULTURAL COLLEGES, AND OTHER NONFEDERAL RESEARCH ORGANIZATIONS: VEGETABLE INSECTS. U. S. Dept. Agr., Bur. Ent. and Plant Quar. E–644f: 1, 2. [Processed.]
(57) SPURWAY, C. H.
1938. SOIL TESTING—A PRACTICAL SYSTEM OF SOIL FERTILITY DIAGNOSIS. Mich. Agr. Expt. Sta. Bul. 32, 23 pp.
(58) TATE, H. D., HILL, R. E., and GATES, D. B.
1945. EXPERIMENTS WITH DDT CONDUCTED BY STATE [NEBRASKA] AGRICULTURAL EXPERIMENT STATIONS, AGRICULTURAL COLLEGES, AND OTHER NONFEDERAL RESEARCH ORGANIZATIONS: VEGETABLES INSECTS. U. S. Dept. Agr., Bur. Ent. and Plant Quar. E–644e: 2–4. [Processed.]
(59) TELFORD, E. A., and CHILDERS, N. F.
1947. TROPICAL KUDZU IN PUERTO RICO. Puerto Rico (Mayaguez) Fed. Expt. Sta. Cir. 27, 30 pp., illus.
(60) TUCKER, C. M.
1927. VANILLA ROOT ROT. Jour. Agr. Res. 35: 1121–1136, illus.
(61) WHITE, D. G.
1948. PROPAGATION OF BAMBOO BY BRANCH CUTTINGS. Amer. Soc. Hort. Sci. Proc. 50: 392–394, illus.
(62) ———, and HUYKE, J. B.
1947. BAMBOO PRODUCTION AND INDUSTRIALIZATION: PROPAGATION AND DISTRIBUTION. Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt. 1946: 34–35.
(63) ———, JONES, M. A., and PAGÁN, C.
1946. INSECTICIDAL-CROP INVESTIGATIONS: PROPAGATION. Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt. 1945: 4–6.
(64) ———, JONES, M. A., and PAGÁN, C.
1947. INSECTICIDAL-CROP INVESTIGATIONS: PROPAGATION. Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt. 1946: 5–6.
(65) ———, PAGÁN, C., and JONES, M. A.
1948. PRODUCTION OF DERRIS ELLIPTICA IN RELATION TO TYPE OF CUTTING AND AGE AT HARVEST. Jour. Agr. Res. 77: 13–24, illus.
(66) ———, PAGÁN, C. and MANGUAL, J. C.
1948. THE EFFECTS OF MULCHING DERRIS ELLIPTICA. Trop Agr. [Trinidad] [In press.]
(67) ———, and VILLAFAÑE, A. G.
1947. BAMBOO PRODUCTION AND INDUSTRIALIZATION: SEED STORAGE. Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt. 1946: 35.
(68) WINTERS, H. F.
1947. DRUG-CROP INVESTIGATIONS: CINCHONA PROPAGATION. Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt. 1946: 13–18.

(69) ———, LOUSTALOT, A. J., and CHILDERS, N. F.
1947. INFLUENCE OF TEMPERATURE ON GROWTH AND ALKALOID CONTENT OF CINCHONA SEEDLINGS. Plant Physiol. 22: 42–50, illus.
(70) ———, LOUSTALOT, A. J., and CHILDERS, N. F.
1947. DRUG-CROP INVESTIGATIONS: PHYSIOLOGICAL STUDIES. Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt. 1946: 18–20.
(71) WOLCOTT, G. N.
1936. "INSECTAE BORINQUENSES." A REVISED ANNOTATED CHECK-LIST OF THE INSECTS OF PUERTO RICO. With a host-plant index by José L. OTERO. Puerto Rico Univ. Jour. Agr. 20: 1–627, illus.
(72) ———
1947. THE PERMANENCE OF TERMITE REPELLENTS. Jour. Econ. Ent. 40: 124–129.

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